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(71)Applicant : **SHARP CORP**
(72)Inventor : **SUGAWARA SATOSHI**
KONDO MASAFUMI
YAMADA EIJI
TAKAHIRA YOSHIYUKI

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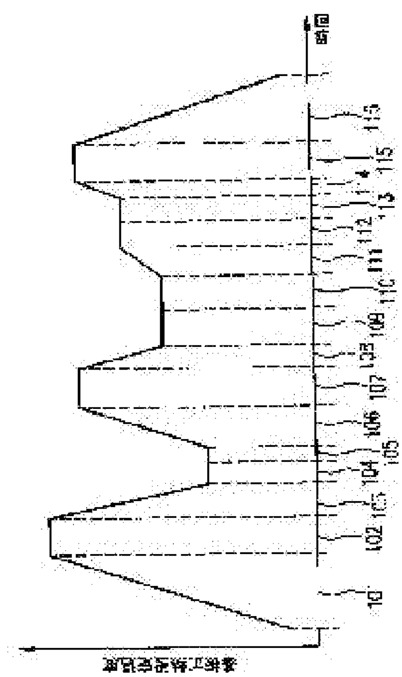
(54) METHOD OF MANUFACTURING NITRIDE-BASED COMPOUND SEMICONDUCTOR LIGHT EMITTING ELEMENT

(57)Abstract:

PROBLEM TO BE SOLVED: To increase the emission intensity of a nitride-based compound semiconductor light-emitting element, provided with an AlGaN protective layer on an InGaN quantum well active layer, and at the same time, to improve the in-plane uniformity of the element.

SOLUTION: After a step 110 of growing an active layer 4, a step 111 of interrupting growth is provided to raise the temperature of a substrate during the period of the step 111. Then, after a step 112 of continuing the growth interruption for a fixed period of time, a step 113 of growing an AlGaN protective layer at the raised temperature is performed. Therefore, the crystallinity and flatness of the AlGaN protective film are improved, and at the same time, uniformity of carrier concentration, etc., is also improved.



CLAIMS

[Claim(s)]

[Claim 1]On an active layer which consists of a nitride based compound semiconductor layer, $aluminum_yGa_{1-y}N$ (0<=y<=1), It is the method of manufacturing a nitride based compound semiconductor light emitting element which has a protective layer which consists of $aluminum_yGa_{1-y}N_jAs_{1-j}$ (0<=y<=1, 0< j<1) or $aluminum_yGa_{1-y}N_kP_{1-k}$ (0<=y<=1, 0< k<1), A manufacturing method of a nitride based compound semiconductor light emitting element which grows this protective layer at temperature which provided a growth interruption period after growth of this active layer, carried out temperature up of the substrate temperature during [the] the growth interruption, and carried out temperature up after that.

[Claim 2]On an active layer which consists of a nitride based compound semiconductor layer, $aluminum_yGa_{1-y}N$ (0<=y<=1), It is the method of manufacturing a nitride based compound semiconductor light emitting element which has a protective layer which consists of $aluminum_yGa_{1-y}N_jAs_{1-j}$ (0<=y<=1, 0< j<1) or $aluminum_yGa_{1-y}N_kP_{1-k}$ (0<=y<=1, 0< k<1), A manufacturing method of a nitride based compound semiconductor light emitting element which grows this protective layer while providing a growth interruption period after growth of this active layer, carrying out temperature up of the substrate temperature during [the] the growth interruption and carrying out temperature up of the substrate temperature further after that.

[Claim 3]On an active layer which consists of a nitride based compound semiconductor layer, $aluminum_yGa_{1-y}N$ (0<=y<=1), It is the method of manufacturing a nitride based compound semiconductor light emitting element which has a protective layer which consists of $aluminum_yGa_{1-y}N_jAs_{1-j}$ (0<=y<=1, 0< j<1) or $aluminum_yGa_{1-y}N_kP_{1-k}$ (0<=y<=1, 0< k<1), A process of providing a growth interruption period after growth of this active layer, and carrying out temperature up of the substrate temperature during [the] the growth interruption, At the temperature which carried out temperature up, then, an $aluminum_yGa_{1-y}N$ layer, A manufacturing method of a nitride based compound semiconductor light emitting element which repeats a process of growing up an $aluminum_yGa_{1-y}N_jAs_{1-j}$ layer or an $aluminum_yGa_{1-y}N_kP_{1-k}$ layer, twice or more, and forms this protective layer.

[Claim 4]A manufacturing method of the nitride based compound semiconductor light emitting element according to any one of claims 1 to 3 which carries out temperature up of the substrate temperature during [said] the growth interruption under atmosphere which added V group material gas to the bottom of a nitrogen atmosphere, or nitrogen.

[Claim 5]Said active layer An $In_xGa_{1-x}N$ (0<=x<=1) layer and GaN_zAs_{1-z} (0< z<=1) layer, A GaN_zP_{1-z} (0< z<=1) layer, The nitride based compound semiconductor light emitting element according to any one of claims 1 to 4 containing an $In_xGa_{1-x}N_zAs_{1-z}$ (0<=x<=1, 0< z<=1) layer or an $In_xGa_{1-x}N_zP_{1-z}$ (0<=x<=1, 0< z<=1) layer.

[Translation done.]

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention about the manufacturing method of nitride based compound semiconductor light emitting elements, such as a semiconductor laser and a light emitting diode, On the active layer which consists of a nitride based compound semiconductor layer especially, aluminum$_y$Ga$_{1-y}$N (0<=y<=1), It is related with the manufacturing method of the nitride based compound semiconductor light emitting element which provided the protective layer which consists of aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) or aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1).
[0002]
[Description of the Prior Art]The light emitting device which used the gallium nitride system compound semiconductor for the active layer can be made to emit light on the broad wavelength from blue to orange by adjusting the presentation of each compound semiconductor layer. A general structure of a light emitting diode where this gallium nitride system compound semiconductor was used is shown in drawing 2.
[0003]This light emitting diode on the silicon on sapphire 1, It has the structure which laminated AlN buffer layer 2, the Si-dope n type GaN layer 3, the In$_{0.3}$Ga$_{0.7}$N single quantum well active layer 4, the Mg-doped-p-type aluminum$_{0.1}$Ga$_{0.9}$N protective layer 5, and Mg-doped-p-type GaN layer 6 one by one. On the p type GaN layer 6, the translucency electrode 8 and the p type electrode 9 are formed, and the n type electrode 7 is formed on the exposed part of the n type GaN layer 3. Here, the protective layer 5 is used in order to protect an active layer from a damage.
[0004]Such a gallium nitride system compound semiconductor light emitting diode is produced through an etching process and an electrode making process, after forming semiconductor laminated structure as shown in drawing 3 by the MOCVD method (organometal chemistry vapor phase growth) conventionally. In this drawing 3, 1-6 show the same thing as drawing 2.
[0005]Drawing 11 is a figure showing change of the substrate-heating preset temperature of each conventional process about the case where the semiconductor laminated structure shown in drawing 3 by the MOCVD method is produced. The manufacturing method of the conventional nitride based compound semiconductor light emitting element is explained referring to this figure.
[0006]First, in the process 801, temperature up of the silicon on sapphire 1 is carried out to 1100 ** from a room temperature. Next, in the process 802, H_2 carrier gas is supplied with the substrate temperature of 1100 **, and substrate cleaning is performed for 20 minutes. Then, in the process 803, H_2 carrier gas is supplied and substrate temperature is lowered from 1100 ** to 550 **. Then, in the process 804, H_2 carrier gas and NH_3 are supplied by 3.5l./, and substrate temperature is stabilized at 550 **. Next, in the process 805, a part for 9micromol/and NH_3 are supplied for H2 carrier gas and trimethylaluminum (TMA) by 3.5l./with the substrate temperature of 550 **, and 35-nm-thick AlN buffer layer 2 is grown up. Then, in the process 806, supply of TMA is suspended, N_2 carrier gas and NH_3 are supplied by 7l./, and temperature up of the substrate temperature is carried out from 550 ** to 1050 **. Then, in the process 807, 7l. a part for /and Silang (SiH_4) are supplied [H_2 carrier gas and trimethylgallium (TMG)] for a part for 50micromol/, and NH_3 by 10nmol/, and the 3-micrometer-thick Si-dope n type GaN layer 3 is grown up. Next, in the process 808, supply of TMG and SiH_4 is suspended, H_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 7l./, and substrate temperature is lowered from 1050 ** to 740 **. Then, in the process 809, N_2 carrier gas and NH_3 are supplied by 7l./, and substrate temperature is

stabilized at 740 **. Then, in the process 810, a part for 17micromol/and NH_3 are supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and trimethylindium (TMI) by 20l./, and the 2-nm-thick $In_{0.3}Ga_{0.7}N$ single quantum well active layer 4 is grown up. Next, in the process 811, with the substrate temperature of 740 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and dicyclopentadienyl magnesium (Cp_2Mg) by 20l./, The 20-nm-thick Mg-doped-p-type $aluminum_{0.1}Ga_{0.9}N$ protective layer 5 is grown up. Then, in the process 812, N_2 carrier gas and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 740 **. Then, in the process 813, a part for 2micromol/and NH_3 are supplied [TMG] for a part for 50micromol/, and Cp_2Mg to H_2 carrier gas by 7l./, and 300-nm-thick Mg-doped-p-type GaN layer 6 is grown up. Finally, in the process 814, H_2 carrier gas and NH_3 are supplied by 7l./, and substrate temperature is lowered. The semiconductor laminated structure shown in drawing 3 by the above processes was produced.
[0007]The process of interrupting growth without supplying a group III material between the process 810 and the process 811 is provided in JP,9-36429,A, and the manufacturing method which grows a p type AlGaN layer with the same substrate temperature after that is indicated.
[0008]
[Problem(s) to be Solved by the Invention]However, as shown in above-mentioned drawing 11, after forming an InGaN quantum well active layer, in the nitride based compound semiconductor light emitting element which formed the AlGaN protective layer continuously, the high luminous efficiency in a 2-inch entire substrate and the homogeneity of luminescence intensity which are made into the purpose are not obtained. Therefore, in an entire substrate, there was a problem that dispersion in luminescence intensity was large and the yield was low. As a cause which such dispersion within a field generates, since the AlGaN layer is grown up at low temperature, it is possible that is bad, and homogeneity, such as carrier concentration, is not good. [of the crystallinity of an AlGaN layer and surface smoothness]
[0009]On the other hand, in the method of JP,9-36429,A, it is improved about the homogeneity of luminescence intensity rather than the manufacturing method which does not establish a growth interruption process by establishing a growth interruption process after growth of an InGaN layer, and growing up an AlGaN layer at the same temperature after that. However, only by such a growth interruption process, it will not result, by the time it secures the homogeneity of luminescence intensity in a 2-inch entire substrate, and improvement in the yield has not fully attained. Therefore, the manufacturing method of the nitride based compound semiconductor light emitting element superior to homogeneous one of high luminous efficiency and luminescence intensity was called for.
[0010]This invention is made that the technical problem of such conventional technology should be solved, and is a thing.
The purpose is to provide the manufacturing method of the nitride based compound semiconductor light emitting element which can produce the nitride based compound semiconductor light emitting element where the strong luminescence intensity which comes out was obtained, and which was excellent with the homogeneity of luminescence intensity.

[0011]
[Means for Solving the Problem]A manufacturing method of a nitride based compound semiconductor light emitting element of this invention, On an active layer which consists of a nitride based compound semiconductor layer, $aluminum_yGa_{1-y}N$ ($0<=y<=1$), It is the method of manufacturing a nitride based compound semiconductor light emitting element which has a protective layer which consists of $aluminum_yGa_{1-y}N_jAs_{1-j}$ ($0<=y<=1$, $0< j<1$) or $aluminum_yGa_{1-y}N_kP_{1-k}$ ($0<=y<=1$, $0< k<1$), A growth interruption period is provided after growth of this active layer, temperature up of the substrate temperature is carried out during [the] the growth interruption, this protective layer is grown up after that at temperature which carried out temperature up, and the above-mentioned purpose is attained by that.
[0012]A manufacturing method of a nitride based compound semiconductor light emitting element of this invention, On an active layer which consists of a nitride based compound semiconductor layer, $aluminum_yGa_{1-y}N$ ($0<=y<=1$), It is the method of manufacturing a nitride based compound semiconductor light emitting element which has a protective layer which consists of $aluminum_yGa_{1-y}N_jAs_{1-j}$ ($0<=y<=1$, $0< j<1$) or $aluminum_yGa_{1-y}N_kP_{1-k}$ ($0<=y<=1$, $0< k<1$), A growth interruption period is provided after growth of this active layer, temperature

up of the substrate temperature is carried out during [the] the growth interruption, this protective layer is grown up, carrying out temperature up of the substrate temperature further after that, and the above-mentioned purpose is attained by that.

[0013]A manufacturing method of a nitride based compound semiconductor light emitting element of this invention, On an active layer which consists of a nitride based compound semiconductor layer, aluminum$_y$Ga$_{1-y}$N (0<=y<=1), It is the method of manufacturing a nitride based compound semiconductor light emitting element which has a protective layer which consists of aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) or aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1), A process of providing a growth interruption period after growth of this active layer, and carrying out temperature up of the substrate temperature during [the] the growth interruption, Then, repeat a process of growing up an aluminum$_y$Ga$_{1-y}$N layer, an aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ layer, or an aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ layer at the temperature which carried out temperature up, twice or more, and this protective layer is formed, The above-mentioned purpose is attained by that.

[0014]It is preferred to carry out temperature up of the substrate temperature during [said] the growth interruption under atmosphere which added V group material gas to the bottom of a nitrogen atmosphere or nitrogen.

[0015]Said active layer An In$_x$Ga$_{1-x}$N (0<=x<=1) layer and GaN$_z$As$_{1-z}$ (0< z<=1) layer, A GaN$_z$P$_{1-z}$ (0< z<=1) layer, the In$_x$Ga$_{1-x}$N$_z$As$_{1-z}$ (0<=x<=1, 0< z<=1) layer, or an In$_x$Ga$_{1-x}$N$_z$P$_{1-z}$ (0<=x<=1, 0< z<=1) layer may be included.

[0016]Hereafter, an operation of this invention is explained.

[0017]If it is in this invention, an In$_x$Ga$_{1-x}$N (0<=x<=1) layer, A GaN$_z$As$_{1-z}$ (0< z<=1) layer and GaN$_z$P$_{1-z}$ (0< z<=1) layer, Nitride based compound semiconductors, such as an In$_x$Ga$_{1-x}$N$_z$As$_{1-z}$ (0<=x<=1, 0< z<=1) layer or an In$_x$Ga$_{1-x}$N$_z$P$_{1-z}$ (0<=x<=1, 0< z<=1) layer, after growth of an included active layer a growth interruption period. By providing, carrying out temperature up of the substrate temperature during [the] the growth interruption, and growing up an aluminum$_y$Ga$_{1-y}$N (0<=y<=1) protective layer after that at temperature which carried out temperature up, Since the crystallinity of an AlGaN protective layer and surface evenness are improved and carrier concentration is also equalized, as shown in Embodiment 1 mentioned later, strong luminescence intensity is obtained in an entire substrate, and a nitride based compound semiconductor light emitting element superior to homogeneous one is obtained. As for aluminum mixed crystal ratio of an AlGaN protective layer, since protection of an active layer will become insufficient if the aluminum mixed crystal ratio y of an aluminum$_y$Ga$_{1-y}$N (0<=y<=1) protective layer is too high, it is preferred that it is [or more 0] 0.2 or less. The same may be said of a case where an aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) protective layer or an aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1) protective layer is used as a protective layer.

[0018]Or an In$_x$Ga$_{1-x}$N (0<=x<=1) layer and GaN$_z$As$_{1-z}$ (0< z<=1) layer, A GaN$_z$P$_{1-z}$ (0< z<=1) layer, Nitride based compound semiconductors, such as an In$_x$Ga$_{1-x}$N$_z$As$_{1-z}$ (0<=x<=1, 0< z<=1) layer or an In$_x$Ga$_{1-x}$N$_z$P$_{1-z}$ (0<=x<=1, 0< z<=1) layer, after growth of an included active layer a growth interruption period. by growing up shows an aluminum$_y$Ga$_{1-y}$N (0<=y<=1) protective layer to Embodiment 2 mentioned later, providing, carrying out temperature up of the substrate temperature during [the] the growth interruption, and carrying out temperature up of the substrate temperature further after that -- as -- further -- an increase in luminescence intensity, and a field of luminescence intensity -- internal division -- equalization of cloth can be attained. The same may be said of a case where an aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) protective layer or an aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1) protective layer is used as a protective layer.

[0019]Or an In$_x$Ga$_{1-x}$N (0<=x<=1) layer and GaN$_z$As$_{1-z}$ (0< z<=1) layer, A GaN$_z$P$_{1-z}$ (0< z<=1) layer, Nitride based compound semiconductors, such as an In$_x$Ga$_{1-x}$N$_z$As$_{1-z}$ (0<=x<=1, 0< z<=1) layer or an In$_x$Ga$_{1-x}$N$_z$P$_{1-z}$ (0<=x<=1, 0< z<=1) layer, after growth of an included active layer a growth interruption period. By repeating a process of providing and carrying out temperature up of the substrate temperature during [the] the growth interruption, and a process of growing up an aluminum$_y$Ga$_{1-y}$N layer after that at the temperature which carried out temperature up, twice or more, it is shown in Embodiment 3 mentioned later -- as -- further -- an increase in luminescence intensity, and a field of luminescence intensity -- internal division -- equalization of cloth can be attained. The same may be said of a case where an aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) protective layer or

an aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1) protective layer is used as a protective layer.
[0020]Since reevaporation of InN from an In$_x$Ga$_{1-x}$N (0<=x<=1) quantum well active layer is controlled by carrying out temperature up of the substrate temperature during the above-mentioned growth interruption under atmosphere which added V group material gas to the bottom of a nitrogen atmosphere, or nitrogen, improvement in the characteristic can be aimed at more. GaN$_z$As$_{1-z}$ (0< z<=1) and GaN$_z$P$_{1-z}$ (0< z<=1), Even when a quantum well active layer which consists of In$_x$Ga$_{1-x}$N$_z$As$_{1-z}$ (0<=x<=1, 0< z<=1) or In$_x$Ga$_{1-x}$N$_z$P$_{1-z}$ (0<=x<=1, 0< z<=1) is used, Since reevaporation of N from a growth film, As, and P compound happens and the reevaporation is controlled, it is possible to measure improvement in the characteristic by carrying out temperature up of the substrate temperature during the above-mentioned growth interruption under atmosphere which added V group material gas to the bottom of a nitrogen atmosphere, or nitrogen.
[0021]
[Embodiment of the Invention]Below, it explains, referring to drawings for an embodiment of the invention. Following embodiments explain taking the case of manufacture of the nitride based compound semiconductor light emitting diode shown in drawing 2 and drawing 3.
[0022](Embodiment 1) Drawing 1 is a figure showing change of the substrate-heating preset temperature of each process in the manufacturing method of the nitride based compound semiconductor light emitting element of this embodiment. Growth of each semiconductor layer is performed by the MOCVD method.
[0023]First, in the process 101, temperature up of the silicon on sapphire 1 is carried out to 1100 ** from a room temperature. Next, in the process 102, H_2 carrier gas is supplied by 20l./with the substrate temperature of 1100 **, and substrate cleaning is performed for 20 minutes. Then, in the process 103, substrate temperature is lowered from 1100 ** to 550 **. Then, in the process 104, H_2 carrier gas and NH_3 are supplied by 3.5l./, and substrate temperature is stabilized at 550 **. Next, in the process 105, a part for 9micromol/and NH_3 are supplied for H_2 carrier gas and TMA by 3.5l./with the substrate temperature of 550 **, and 35-nm-thick AlN buffer layer 2 is grown up. Then, in the process 106, supply of TMA is suspended, N_2 carrier gas and NH_3 are supplied by 3.5l./, and temperature up of the substrate temperature is carried out from 550 ** to 1050 **. Then, in the process 107, a part for 7l./and SiH_4 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and NH_3 by 10nmol/, and the 4-micrometer-thick Si-dope n type GaN layer 3 is grown up. Next, in the process 108, supply of TMG and SiH_4 is suspended, H_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 7l./, and substrate temperature is lowered from 1050 ** to 740 **. Then, in the process 109, N_2 carrier gas and NH_3 are supplied by 7l./, and substrate temperature is stabilized at 740 **. Then, in the process 110, a part for 17micromol/and NH_3 are supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./, and the 2-nm-thick $In_{0.3}Ga_{0.7}N$ single quantum well active layer 4 is grown up.
[0024]Next, in the process 111, supply of TMG and TMI is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 740 ** to 840 ** in 160 seconds. Then, in the process 112, N_2 carrier gas and NH_3 are supplied by 20l./, substrate temperature is kept at 840 **, and growth interruption is continued for 160 seconds.
[0025]Then, in the process 113, with the substrate temperature of 840 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 26-nm-thick Mg-doped-p-type aluminum$_{0.1}$Ga$_{0.9}$N protective layer 5 is grown up. Next, in the process 114, N_2 carrier gas and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 840 **. Then, in the process 115, a part for 2micromol/and NH_3 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and Cp_2Mg by 7l./, and 300-nm-thick Mg-doped-p-type GaN layer 6 is grown up. Then, in the process 116, NH_3 is supplied to H_2 carrier gas by 7l./, and substrate temperature is lowered. The semiconductor laminated structure shown in drawing 3 by the above is produced.
[0026]Next, annealing for Mg activation is performed for 20 minutes at 800 ** among N_2 atmosphere. Then, the Si-dope n type GaN layer 3 is exposed in part by dry etching, the n type electrode 7, the p type translucency electrode 8, and the p type electrode 9 are formed, and the LED structure shown in drawing 2 is produced.
[0027]Thus, after formation of an InGaN quantum well active layer, establish the growth interruption process for

160 seconds, and temperature up of the substrate temperature is carried out, The growth interruption process for 160 seconds is continued at the temperature which carried out temperature up, and the result of having investigated the growing temperature of the AlGaN protective layer as a parameter is shown in drawing 4 after that about the luminescence intensity of the light emitting diode which grew and produced the AlGaN protective layer at the temperature which carried out temperature up. Here, the maximum and the minimum of luminescence intensity of a light emitting diode in a 2-inch wafer side are shown, and - shows the average value.

[0028]As shown in this drawing 4, temperature up of the substrate temperature is carried out during the growth interruption before formation of an AlGaN protective layer after forming an InGaN quantum well active layer, After continuing growth interruption at the temperature furthermore, by forming an AlGaN protective layer at the temperature which carried out temperature up, It turns out that luminescence intensity increases compared with the case (the line and - at the left end of a figure) where continued with the substrate temperature and an AlGaN protective layer is formed after forming an InGaN active layer, and the distribution within a field decreases.

[0029]according to invention-in-this-application persons' examination, it is shown in drawing 4 -- as -- the growing temperature of the AlGaN protective layer after a growth interruption temperature rising step -- the not less than 750 ** range of 1050 ** or less -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- reduction in cloth was seen. In order that the improvement of the surface smoothness of an AlGaN protective layer might not progress when the growing temperature of an AlGaN protective layer is lower than 750 ** even if it establishes a growth interruption process, the improvement of an element characteristic was not found. On the other hand, when the growing temperature of an AlGaN protective layer was higher than 1100 **, it turned out that the damage of InN of an InGaN active layer evaporating with heat is received, and luminescence intensity falls. The growing temperature of an AlGaN protective layer is 800 ** - 1100 ** more preferably, and they are 850 ** - 1050 ** still more preferably.

[0030]The result of having investigated the dependency over growth interruption time about the average value within a field of the luminescence intensity of a light emitting diode is shown in drawing 5. Here, the case where an AlGaN protective layer is grown up in 740 to 1000 ** is shown.

[0031]According to invention-in-this-application persons' examination, the increase in luminescence intensity was seen for growth interruption time in the range for 20 minutes (1200 seconds) from 10 seconds. Since a heating rate is too quick and a crack occurs here when a heating up time is shorter than 10 seconds, it is not desirable. On the other hand, when a heating up time is longer than 20 minutes, it turns out that the adverse effect of InN of an InGaN active layer evaporating becomes strong, and luminescence intensity falls.

[0032]Next, the result investigated about the surface smoothness on the surface of an AlGaN protective layer is shown. Establish the growth interruption process for 160 seconds for an InGaN quantum well active layer after growth at 740 **, and 100 ** temperature up of the substrate temperature is carried out, The growth interruption process for 160 seconds is continued at 840 **, and the result of having observed the state on the surface of an AlGaN protective layer with the atomic force microscope (AFM) is shown in drawing 6 after that about the sample which grew the AlGaN protective layer at 840 **. The result of having observed the state on the surface of an AlGaN protective layer by AFM is shown in drawing 7 about the sample which grew the AlGaN protective layer on the other hand succeeding the growth back of an InGaN active layer without performing growth interruption.

[0033]From these figures, after growth of an InGaN quantum well active layer, establish a growth interruption process and temperature up of the substrate temperature is carried out, By continuing a growth interruption process at the temperature furthermore, and growing up an AlGaN protective layer after that at a temperature higher than the growing temperature of an InGaN quantum well active layer showed that the surface evenness of an AlGaN protective layer was improved.

[0034]About the surface evenness of the AlGaN protective layer, the growing temperature of growth interruption time and an AlGaN protective layer was changed, and was investigated in detail. As a result, even if growth interruption time was made into 5 or less seconds, temperature up of the substrate temperature was carried out in the meantime and it grew up the AlGaN protective layer at the elevated temperature rather than the InGaN active layer, the surface smoothness of an AlGaN protective layer has not improved. Even if it produced the light emitting diode on this condition, luminescence intensity and its homogeneous improvement were not found. Therefore, the thing for which the growth interruption process beyond fixed time is established after growth of (1) InGaN active layer, And it turned out that the effect of raising the surface smoothness of an AlGaN protective layer by fulfilling the conditions of both growing up an AlGaN protective layer by an elevated temperature, and raising luminescence intensity and homogeneity rather than the growing temperature of (2)

InGaN active layer is acquired. In this embodiment, after carrying out temperature up during the growth interruption after InGaN active layer growth, growth interruption was continued further, and the AlGaN protective layer was grown up after that, but even if it did not establish the growth interruption process after this temperature up, surface smoothness has improved slightly and that improvement effect was seen. However, for improvement in the crystallinity of an AlGaN protective layer, and surface smoothness, it is preferred to continue the growth interruption process of fixed time after temperature up. Since it is easy to produce a thermal damage on a ground when temperature-up temperature is high, if downtime is lengthened more than needed, the adverse effect will be considered that become large and luminescence intensity falls. Since such a damage does not arise when temperature-up temperature is low, it is thought that luminescence intensity does not fall even if downtime is long. Therefore, the optimal time changes with temperature-up temperature and heating up times downtime. For example, since it is falling in the downtime for 1200 seconds or more about the case of 840 **, 940 **, and 1000 ** from the value whose luminescence intensity is 0 second according to the graph of drawing 5, it is thought that it is size and the effect of the improvement in luminescence intensity is acquired in less than 1200 seconds from 5 seconds.
[0035]When an AlGaN protective layer is grown up at an elevated temperature rather than an InGaN active layer, even if it reduces the Cp_2Mg flow at the time of AlGaN protective layer growth, strong luminescence intensity is obtained. Therefore, it turned out that the activation rate of Mg dopant is also going up.
[0036]About the thickness of an AlGaN protective layer, when too thin and carrying out temperature up of the substrate temperature for Mg-doped-p-type GaN layer growth, an InGaN active layer was not able to be protected. On the other hand, when the thickness of the AlGaN protective layer was too thick, aggravation of an element characteristic -- resistance of an element increases and driver voltage goes up -- was seen. Therefore, as for the thickness of the AlGaN protective layer, it was preferred that it is the not less than 13-nm range of 50 nm or less, and the improvement effect of an element characteristic and the distribution within a field was seen in this range.
[0037]About aluminum mixed crystal ratio of an AlGaN protective layer, if too low, when carrying out temperature up of the substrate temperature for Mg-doped-p-type GaN layer growth, an AlGaN protective layer deteriorates, and it becomes difficult to protect an InGaN active layer. However, according to the manufacturing method of this invention, even if it used the GaN protective layer, it checked that it was effective to the increase in luminescence intensity, and the improvement of the homogeneity within a field. On the other hand, when aluminum mixed crystal ratio of the AlGaN protective layer was too high, it understood that a crack occurs from the difference in a grating constant, and it becomes impossible to protect an active layer. Therefore, as for aluminum mixed crystal ratio of the AlGaN protective layer, it was preferred that it is [or more 0] 0.2 or less, and the improvement effect of an element characteristic and the distribution within a field was seen in this range.
[0038]Constant temperature temperature up of the substrate temperature is carried out during the growth interruption of the above fixed time, After continuing fixed time growing temperature discontinuation furthermore, the improvement effect of the element characteristic acquired by growing up an AlGaN protective layer at an elevated temperature and the distribution within a field has [one or less / 0 or more] more preferably effective In mixed crystal ratio of an InGaN active layer to the light emitting device of wide or more 0.05 0.9 or less range.
[0039]The growing temperature of an InGaN quantum well active layer is 650 ** - about 800 ** preferably [that it is the range of about 650 ** - about 850 **], and more preferably. the range whose growing temperature of an AlGaN protective layer is 750 ** - 1100 ** as this showed above-mentioned drawing 4 -- more -- desirable -- the range of 800 ** - 1050 ** -- an increase and field of luminescence intensity -- internal division -- it is because it is thought that the reduction effect of cloth is acquired and the optimal growing temperature is 850 ** - about 1050 **. However, since the maximal growth temperature of InGaN changes with In mixed crystal ratios, when In mixed crystal ratio is high, growing temperature is made low, and when In mixed crystal ratio is low, it is thought preferred to make growing temperature high.
[0040](Embodiment 2) This embodiment explains the example which grew the AlGaN protective layer while carrying out temperature up of the substrate temperature.
[0041]Drawing 8 is a figure showing change of the substrate-heating preset temperature of each process in the manufacturing method of the nitride based compound semiconductor light emitting element of this embodiment. Growth of each semiconductor layer is performed by the MOCVD method.
[0042]First, the process 110 is performed like Embodiment 1 from the process 101.
[0043]Next, in the process 111, supply of TMG and TMI is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 740 ** to 840 ** in 160 seconds.

[0044]Then, in the process 113, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 26-nm-thick Mg-doped-p-type aluminum$_{0.1}$Ga$_{0.9}$N protective layer 5 is grown up carrying out temperature up of the substrate temperature from 840 ** to 940 **. Then, in the process 114, N_2 carrier gas and NH3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 940 **.
[0045]Next, the semiconductor laminated structure which performed the process 115 and the process 116 like Embodiment 1, and was shown in drawing 3 is produced.
[0046]Then, dry etching for exposing annealing and the Si-dope n type GaN layer 3 for Mg activation in part is performed like Embodiment 1, and the LED structure which formed the n type electrode 7, the p type translucency electrode 8, and the p type electrode 9, and was shown in drawing 2 is produced.
[0047]Thus, according to the light emitting diode of this embodiment which grew the AlGaN protective layer while establishing the growth interruption process, carrying out temperature up of the substrate temperature after formation of an InGaN quantum well active layer and carrying out temperature up of the substrate temperature further after that. It turns out that the increase in luminescence intensity and the effect of distribution reduction of luminescence intensity become still larger. This is considered because it can control In re-evaporating an AlGaN protective layer from an InGaN quantum well active layer with heat by growing up, and having an adverse effect, carrying out temperature up of the substrate temperature.
[0048]By not less than 750 ** 1100 ** or less, more preferably, if the temperature up of the substrate temperature under AlGaN protective layer growth is within the limits of not less than 800 ** 1050 **, the luminescence intensity of the obtained light emitting device can increase, and it can reduce distribution of luminescence intensity.
[0049](Embodiment 3) This embodiment explains the example grown up while changing the growing temperature of an AlGaN protective layer stair-like.
[0050]Drawing 9 is a figure showing change of the substrate-heating preset temperature of each process in the manufacturing method of the nitride based compound semiconductor light emitting element of this embodiment. Growth of each semiconductor layer is performed by the MOCVD method.
[0051]First, the process 110 is performed like Embodiment 1 from the process 101.
[0052]Next, in the process 111, supply of TMG and TMI is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 740 ** to 840 ** in 160 seconds. Then, in the process 112, N_2 carrier gas and NH_3 are supplied by 20l./, substrate temperature is kept at 840 **, and growth interruption is continued for 160 seconds.
[0053]Then, in the process 113, with the substrate temperature of 840 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 1st 13-nm-thick Mg-doped-p-type aluminum$_{0.1}$Ga$_{0.9}$N protective layer 5 is grown up. Next, in the process 716, supply of TMG and TMA is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 840 ** to 940 ** in 160 seconds. Then, in the process 717, N_2 carrier gas and NH_3 are supplied by 20l./, substrate temperature is kept at 940 **, and growth interruption is continued for 160 seconds. Then, in the process 718, with the substrate temperature of 940 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 2nd 13-nm-thick Mg-doped-p-type aluminum$_{0.1}$Ga$_{0.9}$N protective layer 5 is grown up. Next, in the process 114, N_2 carrier gas and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 940 **.
[0054]Then, the semiconductor laminated structure which performed the process 115 and the process 116 like Embodiment 1, and was shown in drawing 3 is produced.
[0055]Then, dry etching for exposing annealing and the Si-dope n type GaN layer 3 for Mg activation in part is performed like Embodiment 1, and the LED structure which formed the n type electrode 7, the p type translucency electrode 8, and the p type electrode 9, and was shown in drawing 2 is produced.
[0056]Thus, after formation of an InGaN quantum well active layer, establish a growth interruption process and temperature up of the substrate temperature is carried out, It grows up in a part of AlGaN protective layer at the temperature which carried out temperature up, and after establishing a growth interruption process and carrying out temperature up of the substrate temperature after that, according to the light emitting diode of this

embodiment into which the AlGaN protective layer was grown up again, the increase in luminescence intensity and the effect of distribution reduction of luminescence intensity can be enlarged further. This is considered because it can control that distortion of a growth phase is reduced by changing growing temperature, dividing an AlGaN protective layer, and growing up, and In re-evaporating from an InGaN quantum well active layer with heat, and having an adverse effect.
[0057]Although the temperature rising step under growth interruption was put in in between, and the AlGaN protective layer was divided into two-layer with two kinds of growing temperature and was grown up in this embodiment, If the sum total thickness of an AlGaN protective layer is a range which does not exceed 50 nm, even if it repeats the process of growing up an AlGaN protective layer after the temperature rising step under growth interruption, two or more times, luminescence intensity and its homogeneity can be raised similarly.
[0058](Embodiment 4) According to the above-mentioned Embodiment 1 - Embodiment 3, although the active layer of InGaN single quantum well structure was used as an active layer, the active layer of multiple quantum well structure may be used.
[0059]according to this embodiment, a part for 2micromol/and NH_3 being supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./with the substrate temperature of 880 **, and a 5-nm-thick $In_{0.05}Ga_{0.95}N$ layer as a barrier layer, [grow up or] A part for 7micromol/and NH_3 are supplied for N_2 carrier gas and TMG by 20l./, and a 5-nm-thick GaN layer is grown up. As a well layer, a part for 17micromol/and NH_3 are supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./with the substrate temperature of 740 **, and a 2-nm-thick $In_{0.3}Ga_{0.7}N$ layer is grown up.
[0060]Thus, growth of a barrier layer and a well layer is repeated, growth is interrupted after growing up the active layer of multiple quantum well structure, and temperature up of the substrate temperature is carried out to 940 ** in 160 seconds during the growth interruption. Then, after continuing growth interruption for 160 seconds with the substrate temperature of 940 **, an AlGaN protective layer is grown up and a light emitting diode is produced like the above-mentioned Embodiment 1.
[0061]Multiple quantum well structure also with the element used for the active layer Thus, after growth of a multiplex quantum well active layer, growing up an AlGaN protective layer, after establishing the growth interruption process of fixed time, carrying out temperature up of the substrate temperature during [the] the growth interruption and carrying out fixed time continuation of the growth interruption at the temperature -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- the effect of reduction of cloth was able to be acquired.
[0062](Embodiment 5) According to the above-mentioned Embodiment 1 - Embodiment 4, although silicon on sapphire was used as a substrate, substrates, such as a SiC substrate and a GaN board, may be used.
[0063]This embodiment explains manufacture of a nitride based compound semiconductor light emitting diode as shown in drawing 10 as an example which used the GaN board.
[0064]This light emitting diode on the n type GaN board 11, It has the structure which laminated Si-dope GaN buffer layer 12, the Si-dope n type GaN layer 13, the $In_{0.3}Ga_{0.7}N$ single quantum well active layer 14, the Mg-doped-p-type $aluminum_{0.1}Ga_{0.9}N$ protective layer 15, and Mg-doped-p-type GaN layer 16 one by one. On the p type GaN layer 16, the translucency electrode 18 and the p type electrode 19 are formed, and the n type electrode 17 is formed in n type substrate 11 rear face.
[0065]Change of the substrate-heating preset temperature of each process in the manufacturing method of the nitride based compound semiconductor light emitting element of this embodiment is the same as that of drawing 1 shown in Embodiment 1. Growth of each semiconductor layer is performed by the MOCVD method.
[0066]First, in the process 101, temperature up of GaN11 is carried out to 1100 ** from a room temperature. Next, in the process 102, a part for 16.5l./and NH_3 are supplied for H_2 carrier gas by 3.5l./with the substrate temperature of 1100 **, and substrate cleaning is performed for 20 minutes. Then, in the process 103, substrate temperature is lowered from 1100 ** to 550 **. Then, in the process 104, H_2 carrier gas and NH_3 are supplied by 3.5l./, and substrate temperature is stabilized at 550 **. Next, in the process 105, a part for 3.5l./and SiH_4 are supplied [H_2 carrier gas and TMG] for a part for 9micromol/, and NH_3 by 2nmol/with the substrate temperature of 550 **, and 35-nm-thick Si-dope GaN buffer layer 12 is grown up. Then, in the process 106, supply of TMG is suspended, N_2 carrier gas and NH_3 are supplied by 3.5l./, and temperature up of the substrate temperature is carried out from 550 ** to 1050 **. Then, in the process 107, a part for 7l./and SiH_4 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and NH_3 by 10nmol/, and the 0.5-micrometer-thick Si-dope n type

GaN layer 13 is grown up. Next, in the process 108, supply of TMG and SiH_4 is suspended, H_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 7l./, and substrate temperature is lowered from 1050 ** to 740 **. Then, in the process 109, N_2 carrier gas and NH_3 are supplied by 7l./, and substrate temperature is stabilized at 740 **. Then, in the process 110, a part for 17micromol/and NH_3 are supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./, and the 2-nm-thick $In_{0.3}Ga_{0.7}N$ single quantum well active layer 14 is grown up.
[0067]Next, in the process 111, supply of TMG and TMI is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 740 ** to 840 ** in 160 seconds. Then, in the process 112, N_2 carrier gas and NH_3 are supplied by 20l./, substrate temperature is kept at 840 **, and growth interruption is continued for 160 seconds.
[0068]Then, in the process 113, with the substrate temperature of 840 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 26-nm-thick Mg-doped-p-type $aluminum_{0.1}Ga_{0.9}N$ protective layer 15 is grown up. Next, in the process 114, N_2 carrier gas and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 840 **. Then, in the process 115, a part for 2micromol/and NH_3 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and Cp_2Mg by 7l./, and 300-nm-thick Mg-doped-p-type GaN layer 16 is grown up. Then, in the process 116, NH_3 is supplied to H_2 carrier gas by 7l./, and substrate temperature is lowered. Semiconductor laminated structure is produced by the above.
[0069]Next, annealing for Mg activation is performed for 20 minutes at 800 ** among N_2 atmosphere. Then, the n type electrode 17, the p type translucency electrode 18, and the p type electrode 19 are formed, and the LED structure shown in drawing 10 is produced.
[0070]According to this embodiment, by using the GaN board 11, in a substrate and a semiconductor growth layer, a coefficient-of-thermal-expansion difference and lattice constant difference decrease, and the semiconductor growth layer which has better crystallinity can be obtained. The surface smoothness of an AlGaN protective layer can be raised after growth of (1) InGaN active layer by establishing the growth interruption process beyond fixed time, and fulfilling the conditions of both growing up an AlGaN protective layer by an elevated temperature rather than the growing temperature of (2) InGaN active layer.
[0071]The GaN board 11 has conductivity, and since it can form the n type electrode 17 in the rear face of the GaN board 11, it becomes unnecessary [the dry etching process which exposes the n type GaN layer 3 after annealing for Mg activation like Embodiment 1 using silicon on sapphire - Embodiment 3]. The emission area in an element spreads, since it is made to reflect with the n type electrode 17 and luminescence emitted to the substrate side can be taken out effectively, in order to obtain the same luminescence intensity as compared with the element using silicon on sapphire, element size can be made small, and mass production nature can be raised. When it constitutes a LED lamp, by using for the n type electrode 17 the material which has translucency, such as ITO, the grown surface side can be mounted, heat can be more efficiently radiated in an element, and reliability can be raised.
[0072]Although silicon on sapphire was used in the above-mentioned Embodiment 1 - Embodiment 3, even if it uses a GaN board like this embodiment, it is checking that the same effect is acquired. About the plane direction of a GaN board, even if {0001} sides, {1-100} side, {11-20} side, {1-101} side, and {01-12} side are preferred and have shifted from these plane directions twice [**], it is checking that the same effect is acquired.
[0073]Even when a GaN board is used, the active layer of multiple quantum well structure can be used.
[0074]for example, a part for 2micromol/and NH_3 being supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./with the substrate temperature of 880 **, and a 5-nm-thick $In_{0.05}Ga_{0.95}N$ layer as a barrier layer, [grow up or] A part for 7micromol/and NH3 are supplied for N_2 carrier gas and TMG by 20l./, and a 5-nm-thick GaN layer is grown up. As a well layer, a part for 17micromol/and NH_3 are supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./with the substrate temperature of 740 **, and a 2-nm-thick $In_{0.3}Ga_{0.7}N$ layer is grown up.
[0075]Thus, growth of a barrier layer and a well layer is repeated, growth is interrupted after growing up the active layer of multiple quantum well structure, and temperature up of the substrate temperature is carried out to 940 ** in 160 seconds during the growth interruption. Then, after continuing growth interruption for 160 seconds with the substrate temperature of 940 **, an AlGaN protective layer is grown up and a light emitting diode is produced through the annealing process and electrode formation process for Mg activation (p-type-

izing).
[0076]Thus, also with the element which used multiple quantum well structure for the active layer using a GaN board. growing up an AlGaN protective layer, after establishing the growth interruption process of fixed time, carrying out temperature up of the substrate temperature during [the] the growth interruption after growth of a multiplex quantum well active layer and carrying out fixed time continuation of the growth interruption at the temperature -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- the effect of reduction of cloth was able to be acquired.
[0077](Embodiment 6) According to the above-mentioned Embodiment 1 - Embodiment 5, although the InGaN mix crystal system was used as an active layer, GaNAs, GaNP, InGaNAs, or InGaNP may be used.
[0078]This embodiment explains the example which used the n type GaN board and the $In_xGa_{1-x}N_zAs_{1-z}$ (0<=x<=1, 0< z<=1) active layer. Element structure was the same as that of drawing 10 shown in Embodiment 5, and in order to obtain the luminous wavelength of 470 nm as an example, $In_{0.1}Ga_{0.9}N_{0.976}As_{0.024}$ was used for the single quantum well active layer 14.
[0079]Change of the substrate-heating preset temperature of each process in the manufacturing method of the nitride based compound semiconductor light emitting element of this embodiment is the same as that of drawing 1 shown in Embodiment 1. Growth of each semiconductor layer is performed by the MOCVD method.
[0080]First, in the process 101, temperature up of GaN11 is carried out to 1100 ** from a room temperature. Next, in the process 102, a part for 16.5l./and NH_3 are supplied for H_2 carrier gas by 3.5l./with the substrate temperature of 1100 **, and substrate cleaning is performed for 20 minutes. Then, in the process 103, substrate temperature is lowered from 1100 ** to 550 **. Then, in the process 104, H_2 carrier gas and NH_3 are supplied by 3.5l./, and substrate temperature is stabilized at 550 **. Next, in the process 105, a part for 3.5l./and SiH_4 are supplied [H_2 carrier gas and TMG] for a part for 9micromol/, and NH_3 by 2nmol/with the substrate temperature of 550 **, and 35-nm-thick Si-dope GaN buffer layer 12 is grown up. Then, in the process 106, supply of TMG is suspended, N_2 carrier gas and NH_3 are supplied by 3.5l./, and temperature up of the substrate temperature is carried out from 550 ** to 1050 **. Then, in the process 107, a part for 7l./and SiH_4 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and NH_3 by 10nmol/, and the 0.5-micrometer-thick Si-dope n type GaN layer 13 is grown up. Next, in the process 108, supply of TMG and SiH_4 is suspended, H_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 7l./, and substrate temperature is lowered from 1050 ** to 740 **. Then, in the process 109, N_2 carrier gas and NH_3 are supplied by 7l./, and substrate temperature is stabilized at 740 **. Then, in the process 110, supply a part for 7micromol/, and TMI for N_2 carrier gas and TMG, and a part for 20l./and AsH_3 are supplied for a part for 17micromol/, and NH_3 by 10ccm/, The 2-nm-thick $In_{0.1}Ga_{0.9}N_{0.976}As_{0.024}$ single quantum well active layer 14 is grown up.
[0081]Next, in the process 111, supply of TMG, TMI, and AsH_3 is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 740 ** to 840 ** in 160 seconds. Then, in the process 112, N_2 carrier gas and NH_3 are supplied by 20l./, substrate temperature is kept at 840 **, and growth interruption is continued for 160 seconds.
[0082]Then, in the process 113, with the substrate temperature of 840 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 26-nm-thick Mg-doped-p-type $aluminum_{0.1}Ga_{0.9}N$ protective layer 15 is grown up. Next, in the process 114, N_2 carrier gas and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 840 **. Then, in the process 115, a part for 2micromol/and NH_3 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and Cp_2Mg by 7l./, and 300-nm-thick Mg-doped-p-type GaN layer 16 is grown up. Then, in the process 116, NH_3 is supplied to H_2 carrier gas by 7l./, and substrate temperature is lowered. Semiconductor laminated structure is produced by the above.
[0083]Next, annealing for Mg activation is performed for 20 minutes at 800 ** among N_2 atmosphere. Then, the n type electrode 17, the p type translucency electrode 18, and the p type electrode 19 are formed, and the LED structure shown in drawing 10 is produced.
[0084]When it is going to obtain the same luminous wavelength, it is possible by using InGaNAs or InGaNP for an active layer to lessen the presentation of InN which is anxious about the reevaporation in the temperature rising

step after active layer growth compared with the case where InGaN is used for an active layer. It is also possible to use the active layer which does not contain InN at all like GaNAs or GaNP. By this, degradation of the active layer in the temperature rising step by the reevaporation of InN can decrease, the surface smoothness of an AlGaN protective layer can fully be improved, and the luminescence intensity of an element and the distribution within a field can be improved.

[0085]GaNAs, GaNP, InGaNAs, InGaNP, etc. can be used also as the well layer and barrier layer of multiple quantum well structure. Growth of a barrier layer and a well layer is repeated, growth is interrupted after growing up the active layer of multiple quantum well structure, and temperature up of the substrate temperature is carried out to 940 ** in 160 seconds during the growth interruption. Then, after continuing growth interruption for 160 seconds with the substrate temperature of 940 **, an AlGaN protective layer is grown up and a light emitting diode is produced through the annealing process and electrode formation process for Mg activation (p-type-izing).

[0086]Thus, the multiple quantum well structure using the nitride based compound semiconductor containing As or P also with the element used for the active layer. growing up an AlGaN protective layer, after establishing the growth interruption process of fixed time, carrying out temperature up of the substrate temperature during [the] the growth interruption after growth of a multiplex quantum well active layer and carrying out fixed time continuation of the growth interruption at the temperature -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- the effect of reduction of cloth was able to be acquired.

[0087]Although crystal growth was performed by the MOCVD method in the above-mentioned Embodiment 1 - Embodiment 6, it is also possible to use other growing methods, such as an MBE technique. Although the light emitting diode was explained as an example as a light emitting device, this invention is applicable also to a semiconductor laser element. Although N_2 carrier gas or N_2 carrier gas, and NH_3 were supplied during growth interruption and temperature up of the substrate temperature was carried out, When As and P are included in an active layer as a V group material in addition to N, temperature up of the substrate temperature may be carried out under the atmosphere which added V group material gas, such as AsH_3 and PH_3, to nitrogen.

[0088]Although the above-mentioned Embodiment 1 - Embodiment 6 explained the example which grew up the aluminum$_y$Ga$_{1-y}$N (0<=y<=1) protective layer on the active layer, The same effect is acquired also about the case where the protective layer which consists of aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) or aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1) is grown up.

[0089]

[Effect of the Invention]As explained in full detail above, according to this invention, provide a growth interruption period after growth of the active layer containing a nitride based compound semiconductor, and temperature up of the substrate temperature is carried out during [the] the growth interruption, Then, improve the crystallinity of a protective layer, and surface evenness substantially by growing up the protective layer which consists of AlGaN, AlGaNAs, or AlGaNP at the temperature which carried out temperature up, and. Since Carrier's (Mg) activation rate can be improved, luminescence intensity is high and the nitride based compound semiconductor light emitting element excellent in homogeneity can be obtained.

[0090]By growing up the protective layer which consists of AlGaN, AlGaNAs, or AlGaNP while carrying out temperature up of the substrate temperature further, after carrying out temperature up of the substrate temperature during the growth interruption, controlling the reevaporation of In from an active layer -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- the homogeneity of cloth can be raised more.

[0091]Or by repeating the process of carrying out temperature up of the substrate temperature, and the process of growing up an AlGaN layer, an AlGaNAs layer, or an AlGaNP layer after that at the temperature which carried out temperature up, twice or more, and forming a protective layer during the growth interruption, since distortion of a growth phase is reduced and the reevaporation of In from an active layer can be controlled -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- the homogeneity of cloth can be raised more.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention]This invention about the manufacturing method of nitride based compound semiconductor light emitting elements, such as a semiconductor laser and a light emitting diode, On the active layer which consists of a nitride based compound semiconductor layer especially, aluminum$_y$Ga$_{1-y}$N (0<=y<=1), It is related with the manufacturing method of the nitride based compound semiconductor light emitting element which provided the protective layer which consists of aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) or aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1).

[Translation done.]

PRIOR ART

[Description of the Prior Art]The light emitting device which used the gallium nitride system compound semiconductor for the active layer can be made to emit light on the broad wavelength from blue to orange by adjusting the presentation of each compound semiconductor layer. A general structure of a light emitting diode where this gallium nitride system compound semiconductor was used is shown in drawing 2.

[0003]This light emitting diode on the silicon on sapphire 1, It has the structure which laminated AlN buffer layer 2, the Si-dope n type GaN layer 3, the $In_{0.3}Ga_{0.7}N$ single quantum well active layer 4, the Mg-doped-p-type aluminum$_{0.1}Ga_{0.9}N$ protective layer 5, and Mg-doped-p-type GaN layer 6 one by one. On the p type GaN layer 6, the translucency electrode 8 and the p type electrode 9 are formed, and the n type electrode 7 is formed on the exposed part of the n type GaN layer 3. Here, the protective layer 5 is used in order to protect an active layer from a damage.

[0004]Such a gallium nitride system compound semiconductor light emitting diode is produced through an etching process and an electrode making process, after forming semiconductor laminated structure as shown in drawing 3 by the MOCVD method (organometal chemistry vapor phase growth) conventionally. In this drawing 3, 1-6 show the same thing as drawing 2.

[0005]Drawing 11 is a figure showing change of the substrate-heating preset temperature of each conventional process about the case where the semiconductor laminated structure shown in drawing 3 by the MOCVD method is produced. The manufacturing method of the conventional nitride based compound semiconductor light emitting element is explained referring to this figure.

[0006]First, in the process 801, temperature up of the silicon on sapphire 1 is carried out to 1100 ** from a room temperature. Next, in the process 802, H_2 carrier gas is supplied with the substrate temperature of 1100 **, and substrate cleaning is performed for 20 minutes. Then, in the process 803, H_2 carrier gas is supplied and substrate temperature is lowered from 1100 ** to 550 **. Then, in the process 804, H_2 carrier gas and NH_3 are supplied by 3.5l./, and substrate temperature is stabilized at 550 **. Next, in the process 805, a part for 9micromol/and NH_3 are supplied for H2 carrier gas and trimethylaluminum (TMA) by 3.5l./with the substrate temperature of 550 **, and 35-nm-thick AlN buffer layer 2 is grown up. Then, in the process 806, supply of TMA is suspended, N_2 carrier gas and NH_3 are supplied by 7l./, and temperature up of the substrate temperature is carried out from 550 ** to 1050 **. Then, in the process 807, 7l. a part for /and Silang (SiH_4) are supplied [H_2 carrier gas and trimethylgallium (TMG)] for a part for 50micromol/, and NH_3 by 10nmol/, and the 3-micrometer-thick Si-dope n type GaN layer 3 is grown up. Next, in the process 808, supply of TMG and SiH_4 is suspended, H_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 7l./, and substrate temperature is lowered from 1050 ** to 740 **. Then, in the process 809, N_2 carrier gas and NH_3 are supplied by 7l./, and substrate temperature is stabilized at 740 **. Then, in the process 810, a part for 17micromol/and NH_3 are supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and trimethylindium (TMI) by 20l./, and the 2-nm-thick $In_{0.3}Ga_{0.7}N$ single quantum well active layer 4 is grown up. Next, in the process 811, with the substrate temperature of 740 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and dicyclopentadienyl magnesium (Cp_2Mg) by 20l./, The 20-nm-thick Mg-doped-p-type

$aluminum_{0.1}Ga_{0.9}N$ protective layer 5 is grown up. Then, in the process 812, N_2 carrier gas and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 740 **. Then, in the process 813, a part for 2micromol/and NH_3 are supplied [TMG] for a part for 50micromol/, and Cp_2Mg to H_2 carrier gas by 7l./, and 300-nm-thick Mg-doped-p-type GaN layer 6 is grown up. Finally, in the process 814, H_2 carrier gas and NH_3 are supplied by 7l./, and substrate temperature is lowered. The semiconductor laminated structure shown in drawing 3 by the above processes was produced.

[0007]The process of interrupting growth without supplying a group III material between the process 810 and the process 811 is provided in JP,9-36429,A, and the manufacturing method which grows a p type AlGaN layer with the same substrate temperature after that is indicated.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention]As explained in full detail above, in this invention, provide a growth interruption period after growth of the active layer containing a nitride based compound semiconductor, and temperature up of the substrate temperature is carried out during [the] the growth interruption, Then, the crystallinity of a protective layer and surface evenness are substantially improved by growing up the protective layer which consists of AlGaN, AlGaNAs, or AlGaNP at the temperature which carried out temperature up, and Carrier's (Mg) activation rate can be improved.
Therefore, luminescence intensity is high and the nitride based compound semiconductor light emitting element excellent in homogeneity can be obtained.

[0090]By growing up the protective layer which consists of AlGaN, AlGaNAs, or AlGaNP while carrying out temperature up of the substrate temperature further, after carrying out temperature up of the substrate temperature during the growth interruption, controlling the reevaporation of In from an active layer -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- the homogeneity of cloth can be raised more.
[0091]Or by repeating the process of carrying out temperature up of the substrate temperature, and the process of growing up an AlGaN layer, an AlGaNAs layer, or an AlGaNP layer after that at the temperature which carried out temperature up, twice or more, and forming a protective layer during the growth interruption, since distortion of a growth phase is reduced and the reevaporation of In from an active layer can be controlled -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- the homogeneity of cloth can be raised more.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]However, as shown in above-mentioned drawing 11, after forming an InGaN quantum well active layer, in the nitride based compound semiconductor light emitting element which formed the AlGaN protective layer continuously, the high luminous efficiency in a 2-inch entire substrate and the homogeneity of luminescence intensity which are made into the purpose are not obtained. Therefore, in an entire substrate, there was a problem that dispersion in luminescence intensity was large and the yield was low. As a cause which such dispersion within a field generates, since the AlGaN layer is grown up at low temperature, it is possible that is bad, and homogeneity, such as carrier concentration, is not good. [of the crystallinity of an AlGaN layer and surface smoothness]
[0009]On the other hand, in the method of JP,9-36429,A, it is improved about the homogeneity of luminescence intensity rather than the manufacturing method which does not establish a growth interruption process by establishing a growth interruption process after growth of an InGaN layer, and growing up an AlGaN layer at the same temperature after that. However, only by such a growth interruption process, it will not result, by the time it secures the homogeneity of luminescence intensity in a 2-inch entire substrate, and improvement in the yield has not fully attained. Therefore, the manufacturing method of the nitride based compound semiconductor light emitting element superior to homogeneous one of high luminous efficiency and luminescence intensity was called for.
[0010]This invention is made that the technical problem of such conventional technology should be solved, and is a thing.
The purpose is to provide the manufacturing method of the nitride based compound semiconductor light emitting element which can produce the nitride based compound semiconductor light emitting element where the strong luminescence intensity which comes out was obtained, and which was excellent with the homogeneity of luminescence intensity.

[Translation done.]

MEANS

[Means for Solving the Problem]A manufacturing method of a nitride based compound semiconductor light emitting element of this invention, On an active layer which consists of a nitride based compound semiconductor layer, aluminum$_y$Ga$_{1-y}$N (0<=y<=1), It is the method of manufacturing a nitride based compound semiconductor light emitting element which has a protective layer which consists of aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) or aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1), A growth interruption period is provided after growth of this active layer, temperature up of the substrate temperature is carried out during [the] the growth interruption, this protective layer is grown up after that at temperature which carried out temperature up, and the above-mentioned purpose is attained by that.
[0012]A manufacturing method of a nitride based compound semiconductor light emitting element of this invention, On an active layer which consists of a nitride based compound semiconductor layer, aluminum$_y$Ga$_{1-y}$N (0<=y<=1), It is the method of manufacturing a nitride based compound semiconductor light emitting element which has a protective layer which consists of aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) or aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1), A growth interruption period is provided after growth of this active layer, temperature up of the substrate temperature is carried out during [the] the growth interruption, this protective layer is grown up, carrying out temperature up of the substrate temperature further after that, and the above-mentioned purpose is attained by that.
[0013]A manufacturing method of a nitride based compound semiconductor light emitting element of this invention, On an active layer which consists of a nitride based compound semiconductor layer, aluminum$_y$Ga$_{1-y}$N (0<=y<=1), It is the method of manufacturing a nitride based compound semiconductor light emitting element which has a protective layer which consists of aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) or aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1), A process of providing a growth interruption period after growth of this active layer, and carrying out temperature up of the substrate temperature during [the] the growth interruption, Then, repeat a process of growing up an aluminum$_y$Ga$_{1-y}$N layer, an aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ layer, or an aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ layer at the temperature which carried out temperature up, twice or more, and this protective layer is formed, The above-mentioned purpose is attained by that.
[0014]It is preferred to carry out temperature up of the substrate temperature during [said] the growth interruption under atmosphere which added V group material gas to the bottom of a nitrogen atmosphere or nitrogen.
[0015]Said active layer An In$_x$Ga$_{1-x}$N (0<=x<=1) layer and GaN$_z$As$_{1-z}$ (0< z<=1) layer, A GaN$_z$P$_{1-z}$ (0< z<=1) layer, the In$_x$Ga$_{1-x}$N$_z$As$_{1-z}$ (0<=x<=1, 0< z<=1) layer, or an In$_x$Ga$_{1-x}$N$_z$P$_{1-z}$ (0<=x<=1, 0< z<=1) layer may be included.
[0016]Hereafter, an operation of this invention is explained.
[0017]If it is in this invention, an In$_x$Ga$_{1-x}$N (0<=x<=1) layer, A GaN$_z$As$_{1-z}$ (0< z<=1) layer and GaN$_z$P$_{1-z}$ (0< z<=1) layer, Nitride based compound semiconductors, such as an In$_x$Ga$_{1-x}$N$_z$As$_{1-z}$ (0<=x<=1, 0< z<=1) layer or an In$_x$Ga$_{1-x}$N$_z$P$_{1-z}$ (0<=x<=1, 0< z<=1) layer, after growth of an included active layer a growth interruption period. By providing, carrying out temperature up of the substrate temperature during [the] the growth interruption, and growing up an aluminum$_y$Ga$_{1-y}$N (0<=y<=1) protective layer after that at temperature which carried out temperature up, Since the crystallinity of an AlGaN protective layer and surface evenness are improved and

carrier concentration is also equalized, as shown in Embodiment 1 mentioned later, strong luminescence intensity is obtained in an entire substrate, and a nitride based compound semiconductor light emitting element superior to homogeneous one is obtained. As for aluminum mixed crystal ratio of an AlGaN protective layer, since protection of an active layer will become insufficient if the aluminum mixed crystal ratio y of an aluminum$_y$Ga$_{1-y}$N (0<=y<=1) protective layer is too high, it is preferred that it is [or more 0] 0.2 or less. The same may be said of a case where an aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) protective layer or an aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1) protective layer is used as a protective layer.

[0018]Or an In$_x$Ga$_{1-x}$N (0<=x<=1) layer and GaN$_z$As$_{1-z}$ (0< z<=1) layer, A GaN$_z$P$_{1-z}$ (0< z<=1) layer, Nitride based compound semiconductors, such as an In$_x$Ga$_{1-x}$N$_z$As$_{1-z}$ (0<=x<=1, 0< z<=1) layer or an In$_x$Ga$_{1-x}$N$_z$P$_{1-z}$ (0<=x<=1, 0< z<=1) layer, after growth of an included active layer a growth interruption period. by growing up shows an aluminum$_y$Ga$_{1-y}$N (0<=y<=1) protective layer to Embodiment 2 mentioned later, providing, carrying out temperature up of the substrate temperature during [the] the growth interruption, and carrying out temperature up of the substrate temperature further after that -- as -- further -- an increase in luminescence intensity, and a field of luminescence intensity -- internal division -- equalization of cloth can be attained. The same may be said of a case where an aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) protective layer or an aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1) protective layer is used as a protective layer.

[0019]Or an In$_x$Ga$_{1-x}$N (0<=x<=1) layer and GaN$_z$As$_{1-z}$ (0< z<=1) layer, A GaN$_z$P$_{1-z}$ (0< z<=1) layer, Nitride based compound semiconductors, such as an In$_x$Ga$_{1-x}$N$_z$As$_{1-z}$ (0<=x<=1, 0< z<=1) layer or an In$_x$Ga$_{1-x}$N$_z$P$_{1-z}$ (0<=x<=1, 0< z<=1) layer, after growth of an included active layer a growth interruption period. By repeating a process of providing and carrying out temperature up of the substrate temperature during [the] the growth interruption, and a process of growing up an aluminum$_y$Ga$_{1-y}$N layer after that at the temperature which carried out temperature up, twice or more, it is shown in Embodiment 3 mentioned later -- as -- further -- an increase in luminescence intensity, and a field of luminescence intensity -- internal division -- equalization of cloth can be attained. The same may be said of a case where an aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) protective layer or an aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1) protective layer is used as a protective layer.

[0020]Since reevaporation of InN from an In$_x$Ga$_{1-x}$N (0<=x<=1) quantum well active layer is controlled by carrying out temperature up of the substrate temperature during the above-mentioned growth interruption under atmosphere which added V group material gas to the bottom of a nitrogen atmosphere, or nitrogen, improvement in the characteristic can be aimed at more. GaN$_z$As$_{1-z}$ (0< z<=1) and GaN$_z$P$_{1-z}$ (0< z<=1), Even when a quantum well active layer which consists of In$_x$Ga$_{1-x}$N$_z$As$_{1-z}$ (0<=x<=1, 0< z<=1) or In$_x$Ga$_{1-x}$N$_z$P$_{1-z}$ (0<=x<=1, 0< z<=1) is used, Since reevaporation of N from a growth film, As, and P compound happens and the reevaporation is controlled, it is possible to measure improvement in the characteristic by carrying out temperature up of the substrate temperature during the above-mentioned growth interruption under atmosphere which added V group material gas to the bottom of a nitrogen atmosphere, or nitrogen.

[0021]

[Embodiment of the Invention]Below, it explains, referring to drawings for an embodiment of the invention. Following embodiments explain taking the case of manufacture of the nitride based compound semiconductor light emitting diode shown in drawing 2 and drawing 3.

[0022](Embodiment 1) Drawing 1 is a figure showing change of the substrate-heating preset temperature of each process in the manufacturing method of the nitride based compound semiconductor light emitting element of this embodiment. Growth of each semiconductor layer is performed by the MOCVD method.

[0023]First, in the process 101, temperature up of the silicon on sapphire 1 is carried out to 1100 ** from a room temperature. Next, in the process 102, H_2 carrier gas is supplied by 20l./with the substrate temperature of 1100 **, and substrate cleaning is performed for 20 minutes. Then, in the process 103, substrate temperature is lowered from 1100 ** to 550 **. Then, in the process 104, H_2 carrier gas and NH_3 are supplied by 3.5l./, and substrate temperature is stabilized at 550 **. Next, in the process 105, a part for 9micromol/and NH_3 are supplied for H_2 carrier gas and TMA by 3.5l./with the substrate temperature of 550 **, and 35-nm-thick AlN

buffer layer 2 is grown up. Then, in the process 106, supply of TMA is suspended, N_2 carrier gas and NH_3 are supplied by 3.5l./, and temperature up of the substrate temperature is carried out from 550 ** to 1050 **. Then, in the process 107, a part for 7l./and SiH_4 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and NH_3 by 10nmol/, and the 4-micrometer-thick Si-dope n type GaN layer 3 is grown up. Next, in the process 108, supply of TMG and SiH_4 is suspended, H_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 7l./, and substrate temperature is lowered from 1050 ** to 740 **. Then, in the process 109, N_2 carrier gas and NH_3 are supplied by 7l./, and substrate temperature is stabilized at 740 **. Then, in the process 110, a part for 17micromol/and NH_3 are supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./, and the 2-nm-thick $In_{0.3}Ga_{0.7}N$ single quantum well active layer 4 is grown up.

[0024]Next, in the process 111, supply of TMG and TMI is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 740 ** to 840 ** in 160 seconds. Then, in the process 112, N_2 carrier gas and NH_3 are supplied by 20l./, substrate temperature is kept at 840 **, and growth interruption is continued for 160 seconds.

[0025]Then, in the process 113, with the substrate temperature of 840 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 26-nm-thick Mg-doped-p-type $aluminum_{0.1}Ga_{0.9}N$ protective layer 5 is grown up. Next, in the process 114, N_2 carrier gas and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 840 **. Then, in the process 115, a part for 2micromol/and NH_3 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and Cp_2Mg by 7l./, and 300-nm-thick Mg-doped-p-type GaN layer 6 is grown up. Then, in the process 116, NH_3 is supplied to H_2 carrier gas by 7l./, and substrate temperature is lowered. The semiconductor laminated structure shown in drawing 3 by the above is produced.

[0026]Next, annealing for Mg activation is performed for 20 minutes at 800 ** among N_2 atmosphere. Then, the Si-dope n type GaN layer 3 is exposed in part by dry etching, the n type electrode 7, the p type translucency electrode 8, and the p type electrode 9 are formed, and the LED structure shown in drawing 2 is produced.

[0027]Thus, after formation of an InGaN quantum well active layer, establish the growth interruption process for 160 seconds, and temperature up of the substrate temperature is carried out, The growth interruption process for 160 seconds is continued at the temperature which carried out temperature up, and the result of having investigated the growing temperature of the AlGaN protective layer as a parameter is shown in drawing 4 after that about the luminescence intensity of the light emitting diode which grew and produced the AlGaN protective layer at the temperature which carried out temperature up. Here, the maximum and the minimum of luminescence intensity of a light emitting diode in a 2-inch wafer side are shown, and - shows the average value.

[0028]As shown in this drawing 4, temperature up of the substrate temperature is carried out during the growth interruption before formation of an AlGaN protective layer after forming an InGaN quantum well active layer, After continuing growth interruption at the temperature furthermore, by forming an AlGaN protective layer at the temperature which carried out temperature up, It turns out that luminescence intensity increases compared with the case (the line and - at the left end of a figure) where continued with the substrate temperature and an AlGaN protective layer is formed after forming an InGaN active layer, and the distribution within a field decreases.

[0029]according to invention-in-this-application persons' examination, it is shown in drawing 4 -- as -- the growing temperature of the AlGaN protective layer after a growth interruption temperature rising step -- the not less than 750 ** range of 1050 ** or less -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- reduction in cloth was seen. In order that the improvement of the surface smoothness of an AlGaN protective layer might not progress when the growing temperature of an AlGaN protective layer is lower than 750 ** even if it establishes a growth interruption process, the improvement of an element characteristic was not found. On the other hand, when the growing temperature of an AlGaN protective layer was higher than 1100 **, it turned out that the damage of InN of an InGaN active layer evaporating with heat is received, and luminescence intensity falls. The growing temperature of an AlGaN protective layer is 800 ** - 1100 ** more preferably, and they are 850 ** - 1050 ** still more preferably.

[0030]The result of having investigated the dependency over growth interruption time about the average value

within a field of the luminescence intensity of a light emitting diode is shown in drawing 5. Here, the case where an AlGaN protective layer is grown up in 740 to 1000 ** is shown.

[0031]According to invention-in-this-application persons' examination, the increase in luminescence intensity was seen for growth interruption time in the range for 20 minutes (1200 seconds) from 10 seconds. Since a heating rate is too quick and a crack occurs here when a heating up time is shorter than 10 seconds, it is not desirable. On the other hand, when a heating up time is longer than 20 minutes, it turns out that the adverse effect of InN of an InGaN active layer evaporating becomes strong, and luminescence intensity falls.

[0032]Next, the result investigated about the surface smoothness on the surface of an AlGaN protective layer is shown. Establish the growth interruption process for 160 seconds for an InGaN quantum well active layer after growth at 740 **, and 100 ** temperature up of the substrate temperature is carried out, The growth interruption process for 160 seconds is continued at 840 **, and the result of having observed the state on the surface of an AlGaN protective layer with the atomic force microscope (AFM) is shown in drawing 6 after that about the sample which grew the AlGaN protective layer at 840 **. The result of having observed the state on the surface of an AlGaN protective layer by AFM is shown in drawing 7 about the sample which grew the AlGaN protective layer on the other hand succeeding the growth back of an InGaN active layer without performing growth interruption.

[0033]From these figures, after growth of an InGaN quantum well active layer, establish a growth interruption process and temperature up of the substrate temperature is carried out, By continuing a growth interruption process at the temperature furthermore, and growing up an AlGaN protective layer after that at a temperature higher than the growing temperature of an InGaN quantum well active layer showed that the surface evenness of an AlGaN protective layer was improved.

[0034]About the surface evenness of the AlGaN protective layer, the growing temperature of growth interruption time and an AlGaN protective layer was changed, and was investigated in detail. As a result, even if growth interruption time was made into 5 or less seconds, temperature up of the substrate temperature was carried out in the meantime and it grew up the AlGaN protective layer at the elevated temperature rather than the InGaN active layer, the surface smoothness of an AlGaN protective layer has not improved. Even if it produced the light emitting diode on this condition, luminescence intensity and its homogeneous improvement were not found. Therefore, the thing for which the growth interruption process beyond fixed time is established after growth of (1) InGaN active layer, And it turned out that the effect of raising the surface smoothness of an AlGaN protective layer by fulfilling the conditions of both growing up an AlGaN protective layer by an elevated temperature, and raising luminescence intensity and homogeneity rather than the growing temperature of (2) InGaN active layer is acquired. In this embodiment, after carrying out temperature up during the growth interruption after InGaN active layer growth, growth interruption was continued further, and the AlGaN protective layer was grown up after that, but even if it did not establish the growth interruption process after this temperature up, surface smoothness has improved slightly and that improvement effect was seen. However, for improvement in the crystallinity of an AlGaN protective layer, and surface smoothness, it is preferred to continue the growth interruption process of fixed time after temperature up. Since it is easy to produce a thermal damage on a ground when temperature-up temperature is high, if downtime is lengthened more than needed, the adverse effect will be considered that become large and luminescence intensity falls. Since such a damage does not arise when temperature-up temperature is low, it is thought that luminescence intensity does not fall even if downtime is long. Therefore, the optimal time changes with temperature-up temperature and heating up times downtime. For example, since it is falling in the downtime for 1200 seconds or more about the case of 840 **, 940 **, and 1000 ** from the value whose luminescence intensity is 0 second according to the graph of drawing 5, it is thought that it is size and the effect of the improvement in luminescence intensity is acquired in less than 1200 seconds from 5 seconds.

[0035]When an AlGaN protective layer is grown up at an elevated temperature rather than an InGaN active layer, even if it reduces the Cp_2Mg flow at the time of AlGaN protective layer growth, strong luminescence intensity is obtained. Therefore, it turned out that the activation rate of Mg dopant is also going up.

[0036]About the thickness of an AlGaN protective layer, when too thin and carrying out temperature up of the substrate temperature for Mg-doped-p-type GaN layer growth, an InGaN active layer was not able to be protected. On the other hand, when the thickness of the AlGaN protective layer was too thick, aggravation of an element characteristic -- resistance of an element increases and driver voltage goes up -- was seen. Therefore, as for the thickness of the AlGaN protective layer, it was preferred that it is the not less than 13-nm range of 50 nm or less, and the improvement effect of an element characteristic and the distribution within a field was seen in this range.

[0037]About aluminum mixed crystal ratio of an AlGaN protective layer, if too low, when carrying out temperature up of the substrate temperature for Mg-doped-p-type GaN layer growth, an AlGaN protective layer deteriorates, and it becomes difficult to protect an InGaN active layer. However, according to the manufacturing method of this invention, even if it used the GaN protective layer, it checked that it was effective to the increase in luminescence intensity, and the improvement of the homogeneity within a field. On the other hand, when aluminum mixed crystal ratio of the AlGaN protective layer was too high, it understood that a crack occurs from the difference in a grating constant, and it becomes impossible to protect an active layer. Therefore, as for aluminum mixed crystal ratio of the AlGaN protective layer, it was preferred that it is [or more 0] 0.2 or less, and the improvement effect of an element characteristic and the distribution within a field was seen in this range.
[0038]Constant temperature temperature up of the substrate temperature is carried out during the growth interruption of the above fixed time, After continuing fixed time growing temperature discontinuation furthermore, the improvement effect of the element characteristic acquired by growing up an AlGaN protective layer at an elevated temperature and the distribution within a field has [one or less / 0 or more] more preferably effective In mixed crystal ratio of an InGaN active layer to the light emitting device of wide or more 0.05 0.9 or less range.
[0039]The growing temperature of an InGaN quantum well active layer is 650 ** - about 800 ** preferably [that it is the range of about 650 ** - about 850 **], and more preferably. the range whose growing temperature of an AlGaN protective layer is 750 ** - 1100 ** as this showed above-mentioned drawing 4 -- more -- desirable -- the range of 800 ** - 1050 ** -- an increase and field of luminescence intensity -- internal division -- it is because it is thought that the reduction effect of cloth is acquired and the optimal growing temperature is 850 ** - about 1050 **. However, since the maximal growth temperature of InGaN changes with In mixed crystal ratios, when In mixed crystal ratio is high, growing temperature is made low, and when In mixed crystal ratio is low, it is thought preferred to make growing temperature high.
[0040](Embodiment 2) This embodiment explains the example which grew the AlGaN protective layer while carrying out temperature up of the substrate temperature.
[0041]Drawing 8 is a figure showing change of the substrate-heating preset temperature of each process in the manufacturing method of the nitride based compound semiconductor light emitting element of this embodiment. Growth of each semiconductor layer is performed by the MOCVD method.
[0042]First, the process 110 is performed like Embodiment 1 from the process 101.
[0043]Next, in the process 111, supply of TMG and TMI is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 740 ** to 840 ** in 160 seconds.
[0044]Then, in the process 113, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 26-nm-thick Mg-doped-p-type $aluminum_{0.1}Ga_{0.9}N$ protective layer 5 is grown up carrying out temperature up of the substrate temperature from 840 ** to 940 **. Then, in the process 114, N_2 carrier gas and NH3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 940 **.
[0045]Next, the semiconductor laminated structure which performed the process 115 and the process 116 like Embodiment 1, and was shown in drawing 3 is produced.
[0046]Then, dry etching for exposing annealing and the Si-dope n type GaN layer 3 for Mg activation in part is performed like Embodiment 1, and the LED structure which formed the n type electrode 7, the p type translucency electrode 8, and the p type electrode 9, and was shown in drawing 2 is produced.
[0047]Thus, according to the light emitting diode of this embodiment which grew the AlGaN protective layer while establishing the growth interruption process, carrying out temperature up of the substrate temperature after formation of an InGaN quantum well active layer and carrying out temperature up of the substrate temperature further after that. It turns out that the increase in luminescence intensity and the effect of distribution reduction of luminescence intensity become still larger. This is considered because it can control In re-evaporating an AlGaN protective layer from an InGaN quantum well active layer with heat by growing up, and having an adverse effect, carrying out temperature up of the substrate temperature.
[0048]By not less than 750 ** 1100 ** or less, more preferably, if the temperature up of the substrate temperature under AlGaN protective layer growth is within the limits of not less than 800 ** 1050 **, the luminescence intensity of the obtained light emitting device can increase, and it can reduce distribution of luminescence intensity.

[0049](Embodiment 3) This embodiment explains the example grown up while changing the growing temperature of an AlGaN protective layer stair-like.
[0050]Drawing 9 is a figure showing change of the substrate-heating preset temperature of each process in the manufacturing method of the nitride based compound semiconductor light emitting element of this embodiment. Growth of each semiconductor layer is performed by the MOCVD method.
[0051]First, the process 110 is performed like Embodiment 1 from the process 101.
[0052]Next, in the process 111, supply of TMG and TMI is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 740 ** to 840 ** in 160 seconds. Then, in the process 112, N_2 carrier gas and NH_3 are supplied by 20l./, substrate temperature is kept at 840 **, and growth interruption is continued for 160 seconds.
[0053]Then, in the process 113, with the substrate temperature of 840 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 1st 13-nm-thick Mg-doped-p-type aluminum$_{0.1}$Ga$_{0.9}$N protective layer 5 is grown up. Next, in the process 716, supply of TMG and TMA is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 840 ** to 940 ** in 160 seconds. Then, in the process 717, N_2 carrier gas and NH_3 are supplied by 20l./, substrate temperature is kept at 940 **, and growth interruption is continued for 160 seconds. Then, in the process 718, with the substrate temperature of 940 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 2nd 13-nm-thick Mg-doped-p-type aluminum$_{0.1}$Ga$_{0.9}$N protective layer 5 is grown up. Next, in the process 114, N_2 carrier gas and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 940 **.
[0054]Then, the semiconductor laminated structure which performed the process 115 and the process 116 like Embodiment 1, and was shown in drawing 3 is produced.
[0055]Then, dry etching for exposing annealing and the Si-dope n type GaN layer 3 for Mg activation in part is performed like Embodiment 1, and the LED structure which formed the n type electrode 7, the p type translucency electrode 8, and the p type electrode 9, and was shown in drawing 2 is produced.
[0056]Thus, after formation of an InGaN quantum well active layer, establish a growth interruption process and temperature up of the substrate temperature is carried out, It grows up in a part of AlGaN protective layer at the temperature which carried out temperature up, and after establishing a growth interruption process and carrying out temperature up of the substrate temperature after that, according to the light emitting diode of this embodiment into which the AlGaN protective layer was grown up again, the increase in luminescence intensity and the effect of distribution reduction of luminescence intensity can be enlarged further. This is considered because it can control that distortion of a growth phase is reduced by changing growing temperature, dividing an AlGaN protective layer, and growing up, and In re-evaporating from an InGaN quantum well active layer with heat, and having an adverse effect.
[0057]Although the temperature rising step under growth interruption was put in in between, and the AlGaN protective layer was divided into two-layer with two kinds of growing temperature and was grown up in this embodiment, If the sum total thickness of an AlGaN protective layer is a range which does not exceed 50 nm, even if it repeats the process of growing up an AlGaN protective layer after the temperature rising step under growth interruption, two or more times, luminescence intensity and its homogeneity can be raised similarly.
[0058](Embodiment 4) According to the above-mentioned Embodiment 1 - Embodiment 3, although the active layer of InGaN single quantum well structure was used as an active layer, the active layer of multiple quantum well structure may be used.
[0059]according to this embodiment, a part for 2micromol/and NH_3 being supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./with the substrate temperature of 880 **, and a 5-nm-thick $In_{0.05}Ga_{0.95}N$ layer as a barrier layer, [grow up or] A part for 7micromol/and NH_3 are supplied for N_2 carrier gas and TMG by 20l./, and a 5-nm-thick GaN layer is grown up. As a well layer, a part for 17micromol/and NH_3 are supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./with the substrate temperature of 740 **, and a 2-nm-thick $In_{0.3}Ga_{0.7}N$ layer is grown up.

[0060]Thus, growth of a barrier layer and a well layer is repeated, growth is interrupted after growing up the active layer of multiple quantum well structure, and temperature up of the substrate temperature is carried out to 940 ** in 160 seconds during the growth interruption. Then, after continuing growth interruption for 160 seconds with the substrate temperature of 940 **, an AlGaN protective layer is grown up and a light emitting diode is produced like the above-mentioned Embodiment 1.
[0061]Multiple quantum well structure also with the element used for the active layer Thus, after growth of a multiplex quantum well active layer, growing up an AlGaN protective layer, after establishing the growth interruption process of fixed time, carrying out temperature up of the substrate temperature during [the] the growth interruption and carrying out fixed time continuation of the growth interruption at the temperature -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- the effect of reduction of cloth was able to be acquired.
[0062](Embodiment 5) According to the above-mentioned Embodiment 1 - Embodiment 4, although silicon on sapphire was used as a substrate, substrates, such as a SiC substrate and a GaN board, may be used.
[0063]This embodiment explains manufacture of a nitride based compound semiconductor light emitting diode as shown in drawing 10 as an example which used the GaN board.
[0064]This light emitting diode on the n type GaN board 11, It has the structure which laminated Si-dope GaN buffer layer 12, the Si-dope n type GaN layer 13, the $In_{0.3}Ga_{0.7}N$ single quantum well active layer 14, the Mg-doped-p-type aluminum$_{0.1}$Ga$_{0.9}$N protective layer 15, and Mg-doped-p-type GaN layer 16 one by one. On the p type GaN layer 16, the translucency electrode 18 and the p type electrode 19 are formed, and the n type electrode 17 is formed in n type substrate 11 rear face.
[0065]Change of the substrate-heating preset temperature of each process in the manufacturing method of the nitride based compound semiconductor light emitting element of this embodiment is the same as that of drawing 1 shown in Embodiment 1. Growth of each semiconductor layer is performed by the MOCVD method.
[0066]First, in the process 101, temperature up of GaN11 is carried out to 1100 ** from a room temperature. Next, in the process 102, a part for 16.5l./and NH_3 are supplied for H_2 carrier gas by 3.5l./with the substrate temperature of 1100 **, and substrate cleaning is performed for 20 minutes. Then, in the process 103, substrate temperature is lowered from 1100 ** to 550 **. Then, in the process 104, H_2 carrier gas and NH_3 are supplied by 3.5l./, and substrate temperature is stabilized at 550 **. Next, in the process 105, a part for 3.5l./and SiH_4 are supplied [H_2 carrier gas and TMG] for a part for 9micromol/, and NH_3 by 2nmol/with the substrate temperature of 550 **, and 35-nm-thick Si-dope GaN buffer layer 12 is grown up. Then, in the process 106, supply of TMG is suspended, N_2 carrier gas and NH_3 are supplied by 3.5l./, and temperature up of the substrate temperature is carried out from 550 ** to 1050 **. Then, in the process 107, a part for 7l./and SiH_4 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and NH_3 by 10nmol/, and the 0.5-micrometer-thick Si-dope n type GaN layer 13 is grown up. Next, in the process 108, supply of TMG and SiH_4 is suspended, H_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 7l./, and substrate temperature is lowered from 1050 ** to 740 **. Then, in the process 109, N_2 carrier gas and NH_3 are supplied by 7l./, and substrate temperature is stabilized at 740 **. Then, in the process 110, a part for 17micromol/and NH_3 are supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./, and the 2-nm-thick $In_{0.3}Ga_{0.7}N$ single quantum well active layer 14 is grown up.
[0067]Next, in the process 111, supply of TMG and TMI is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 740 ** to 840 ** in 160 seconds. Then, in the process 112, N_2 carrier gas and NH_3 are supplied by 20l./, substrate temperature is kept at 840 **, and growth interruption is continued for 160 seconds.
[0068]Then, in the process 113, with the substrate temperature of 840 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 26-nm-thick Mg-doped-p-type aluminum$_{0.1}$Ga$_{0.9}$N protective layer 15 is grown up. Next, in the process 114, N_2 carrier gas and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 840 **. Then, in the process 115, a part for 2micromol/and NH_3 are supplied [H_2

carrier gas and TMG] for a part for 50micromol/, and Cp_2Mg by 7l./, and 300-nm-thick Mg-doped-p-type GaN layer 16 is grown up. Then, in the process 116, NH_3 is supplied to H_2 carrier gas by 7l./, and substrate temperature is lowered. Semiconductor laminated structure is produced by the above.

[0069]Next, annealing for Mg activation is performed for 20 minutes at 800 ** among N_2 atmosphere. Then, the n type electrode 17, the p type translucency electrode 18, and the p type electrode 19 are formed, and the LED structure shown in drawing 10 is produced.

[0070]According to this embodiment, by using the GaN board 11, in a substrate and a semiconductor growth layer, a coefficient-of-thermal-expansion difference and lattice constant difference decrease, and the semiconductor growth layer which has better crystallinity can be obtained. The surface smoothness of an AlGaN protective layer can be raised after growth of (1) InGaN active layer by establishing the growth interruption process beyond fixed time, and fulfilling the conditions of both growing up an AlGaN protective layer by an elevated temperature rather than the growing temperature of (2) InGaN active layer.

[0071]The GaN board 11 has conductivity, and since it can form the n type electrode 17 in the rear face of the GaN board 11, it becomes unnecessary [the dry etching process which exposes the n type GaN layer 3 after annealing for Mg activation like Embodiment 1 using silicon on sapphire - Embodiment 3]. The emission area in an element spreads, since it is made to reflect with the n type electrode 17 and luminescence emitted to the substrate side can be taken out effectively, in order to obtain the same luminescence intensity as compared with the element using silicon on sapphire, element size can be made small, and mass production nature can be raised. When it constitutes a LED lamp, by using for the n type electrode 17 the material which has translucency, such as ITO, the grown surface side can be mounted, heat can be more efficiently radiated in an element, and reliability can be raised.

[0072]Although silicon on sapphire was used in the above-mentioned Embodiment 1 - Embodiment 3, even if it uses a GaN board like this embodiment, it is checking that the same effect is acquired. About the plane direction of a GaN board, even if {0001} sides, {1-100} side, {11-20} side, {1-101} side, and {01-12} side are preferred and have shifted from these plane directions twice [**], it is checking that the same effect is acquired.

[0073]Even when a GaN board is used, the active layer of multiple quantum well structure can be used.

[0074]for example, a part for 2micromol/and NH_3 being supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./with the substrate temperature of 880 **, and a 5-nm-thick $In_{0.05}Ga_{0.95}N$ layer as a barrier layer, [grow up or] A part for 7micromol/and NH3 are supplied for N_2 carrier gas and TMG by 20l./, and a 5-nm-thick GaN layer is grown up. As a well layer, a part for 17micromol/and NH_3 are supplied [N_2 carrier gas and TMG] for a part for 7micromol/, and TMI by 20l./with the substrate temperature of 740 **, and a 2-nm-thick $In_{0.3}Ga_{0.7}N$ layer is grown up.

[0075]Thus, growth of a barrier layer and a well layer is repeated, growth is interrupted after growing up the active layer of multiple quantum well structure, and temperature up of the substrate temperature is carried out to 940 ** in 160 seconds during the growth interruption. Then, after continuing growth interruption for 160 seconds with the substrate temperature of 940 **, an AlGaN protective layer is grown up and a light emitting diode is produced through the annealing process and electrode formation process for Mg activation (p-type-izing).

[0076]Thus, also with the element which used multiple quantum well structure for the active layer using a GaN board. growing up an AlGaN protective layer, after establishing the growth interruption process of fixed time, carrying out temperature up of the substrate temperature during [the] the growth interruption after growth of a multiplex quantum well active layer and carrying out fixed time continuation of the growth interruption at the temperature -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- the effect of reduction of cloth was able to be acquired.

[0077](Embodiment 6) According to the above-mentioned Embodiment 1 - Embodiment 5, although the InGaN mix crystal system was used as an active layer, GaNAs, GaNP, InGaNAs, or InGaNP may be used.

[0078]This embodiment explains the example which used the n type GaN board and the $In_xGa_{1-x}N_zAs_{1-z}$ ($0<=x<=1$, $0< z<=1$) active layer. Element structure was the same as that of drawing 10 shown in Embodiment 5, and in order to obtain the luminous wavelength of 470 nm as an example, $In_{0.1}Ga_{0.9}N_{0.976}As_{0.024}$ was used for the single quantum well active layer 14.

[0079]Change of the substrate-heating preset temperature of each process in the manufacturing method of the

nitride based compound semiconductor light emitting element of this embodiment is the same as that of drawing 1 shown in Embodiment 1. Growth of each semiconductor layer is performed by the MOCVD method.
[0080]First, in the process 101, temperature up of GaN11 is carried out to 1100 ** from a room temperature. Next, in the process 102, a part for 16.5l./and NH_3 are supplied for H_2 carrier gas by 3.5l./with the substrate temperature of 1100 **, and substrate cleaning is performed for 20 minutes. Then, in the process 103, substrate temperature is lowered from 1100 ** to 550 **. Then, in the process 104, H_2 carrier gas and NH_3 are supplied by 3.5l./, and substrate temperature is stabilized at 550 **. Next, in the process 105, a part for 3.5l./and SiH_4 are supplied [H_2 carrier gas and TMG] for a part for 9micromol/, and NH_3 by 2nmol/with the substrate temperature of 550 **, and 35-nm-thick Si-dope GaN buffer layer 12 is grown up. Then, in the process 106, supply of TMG is suspended, N_2 carrier gas and NH_3 are supplied by 3.5l./, and temperature up of the substrate temperature is carried out from 550 ** to 1050 **. Then, in the process 107, a part for 7l./and SiH_4 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and NH_3 by 10nmol/, and the 0.5-micrometer-thick Si-dope n type GaN layer 13 is grown up. Next, in the process 108, supply of TMG and SiH_4 is suspended, H_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 7l./, and substrate temperature is lowered from 1050 ** to 740 **. Then, in the process 109, N_2 carrier gas and NH_3 are supplied by 7l./, and substrate temperature is stabilized at 740 **. Then, in the process 110, supply a part for 7micromol/, and TMI for N_2 carrier gas and TMG, and a part for 20l./and AsH_3 are supplied for a part for 17micromol/, and NH_3 by 10ccm/, The 2-nm-thick $In_{0.1}Ga_{0.9}N_{0.976}As_{0.024}$ single quantum well active layer 14 is grown up.
[0081]Next, in the process 111, supply of TMG, TMI, and AsH_3 is suspended, N_2 carrier gas or N_2 carrier gas, and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out from 740 ** to 840 ** in 160 seconds. Then, in the process 112, N_2 carrier gas and NH_3 are supplied by 20l./, substrate temperature is kept at 840 **, and growth interruption is continued for 160 seconds.
[0082]Then, in the process 113, with the substrate temperature of 840 **, supply a part for 7micromol/, and TMA for N_2 carrier gas and TMG, and a part for 0.2micromol/and NH_3 are supplied for a part for 0.7micromol/, and Cp_2Mg by 20l./, The 26-nm-thick Mg-doped-p-type $aluminum_{0.1}Ga_{0.9}N$ protective layer 15 is grown up. Next, in the process 114, N_2 carrier gas and NH_3 are supplied by 20l./, and temperature up of the substrate temperature is carried out to 1050 ** from 840 **. Then, in the process 115, a part for 2micromol/and NH_3 are supplied [H_2 carrier gas and TMG] for a part for 50micromol/, and Cp_2Mg by 7l./, and 300-nm-thick Mg-doped-p-type GaN layer 16 is grown up. Then, in the process 116, NH_3 is supplied to H_2 carrier gas by 7l./, and substrate temperature is lowered. Semiconductor laminated structure is produced by the above.
[0083]Next, annealing for Mg activation is performed for 20 minutes at 800 ** among N_2 atmosphere. Then, the n type electrode 17, the p type translucency electrode 18, and the p type electrode 19 are formed, and the LED structure shown in drawing 10 is produced.
[0084]When it is going to obtain the same luminous wavelength, it is possible by using InGaNAs or InGaNP for an active layer to lessen the presentation of InN which is anxious about the reevaporation in the temperature rising step after active layer growth compared with the case where InGaN is used for an active layer. It is also possible to use the active layer which does not contain InN at all like GaNAs or GaNP. By this, degradation of the active layer in the temperature rising step by the reevaporation of InN can decrease, the surface smoothness of an AlGaN protective layer can fully be improved, and the luminescence intensity of an element and the distribution within a field can be improved.
[0085]GaNAs, GaNP, InGaNAs, InGaNP, etc. can be used also as the well layer and barrier layer of multiple quantum well structure. Growth of a barrier layer and a well layer is repeated, growth is interrupted after growing up the active layer of multiple quantum well structure, and temperature up of the substrate temperature is carried out to 940 ** in 160 seconds during the growth interruption. Then, after continuing growth interruption for 160 seconds with the substrate temperature of 940 **, an AlGaN protective layer is grown up and a light emitting diode is produced through the annealing process and electrode formation process for Mg activation (p-type-

izing).
[0086]Thus, the multiple quantum well structure using the nitride based compound semiconductor containing As or P also with the element used for the active layer. growing up an AlGaN protective layer, after establishing the growth interruption process of fixed time, carrying out temperature up of the substrate temperature during [the] the growth interruption after growth of a multiplex quantum well active layer and carrying out fixed time continuation of the growth interruption at the temperature -- the increase in luminescence intensity, and the field of luminescence intensity -- internal division -- the effect of reduction of cloth was able to be acquired.
[0087]Although crystal growth was performed by the MOCVD method in the above-mentioned Embodiment 1 - Embodiment 6, it is also possible to use other growing methods, such as an MBE technique. Although the light emitting diode was explained as an example as a light emitting device, this invention is applicable also to a semiconductor laser element. Although N_2 carrier gas or N_2 carrier gas, and NH_3 were supplied during growth interruption and temperature up of the substrate temperature was carried out, When As and P are included in an active layer as a V group material in addition to N, temperature up of the substrate temperature may be carried out under the atmosphere which added V group material gas, such as AsH_3 and PH_3, to nitrogen.
[0088]Although the above-mentioned Embodiment 1 - Embodiment 6 explained the example which grew up the aluminum$_y$Ga$_{1-y}$N (0<=y<=1) protective layer on the active layer, The same effect is acquired also about the case where the protective layer which consists of aluminum$_y$Ga$_{1-y}$N$_j$As$_{1-j}$ (0<=y<=1, 0< j<1) or aluminum$_y$Ga$_{1-y}$N$_k$P$_{1-k}$ (0<=y<=1, 0< k<1) is grown up.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a figure showing change of the substrate-heating preset temperature in each manufacturing process of the nitride based compound semiconductor light emitting element of Embodiment 1.
[Drawing 2]It is a sectional view showing the outline structure of a general nitride based compound semiconductor light emitting element.
[Drawing 3]It is a sectional view showing the semiconductor laminated structure in the nitride based compound semiconductor light emitting element of drawing 2.
[Drawing 4]It is a figure showing the relation between the growing temperature of an AlGaN protective layer, and the luminescence intensity of a nitride based compound semiconductor light emitting element.
[Drawing 5]It is a figure showing the relation between growth interruption time and the luminescence intensity of a nitride based compound semiconductor light emitting element.
[Drawing 6]It is an AFM observation figure of the surface state of the AlGaN layer which carried out temperature up during the growth interruption, and grew at the elevated temperature.
[Drawing 7]It is an AFM observation figure of the surface state of the AlGaN layer which grew without interrupting growth.
[Drawing 8]It is a figure showing change of the substrate-heating preset temperature in each manufacturing process of the nitride based compound semiconductor light emitting element of Embodiment 2.
[Drawing 9]It is a figure showing change of the substrate-heating preset temperature in each manufacturing process of the nitride based compound semiconductor light emitting element of Embodiment 3.
[Drawing 10]It is a sectional view showing the outline structure of the nitride based compound semiconductor light emitting element of Embodiment 5 and Embodiment 6.
[Drawing 11]It is a figure showing change of the substrate-heating preset temperature in each manufacturing process of the conventional nitride based compound semiconductor light emitting element.
[Description of Notations]
1 Sapphire substrate
2, 12 buffer layers
3, 13 n type GaN layers
4 and 14 Undoped InGaN active layer
5, 15 AlGaN protective layers
6, 16 p type GaN layers
7, 17 n type electrodes
8, 18 p-type translucency electrode
9, 19 p type electrodes
11 GaN board

[Translation done.]

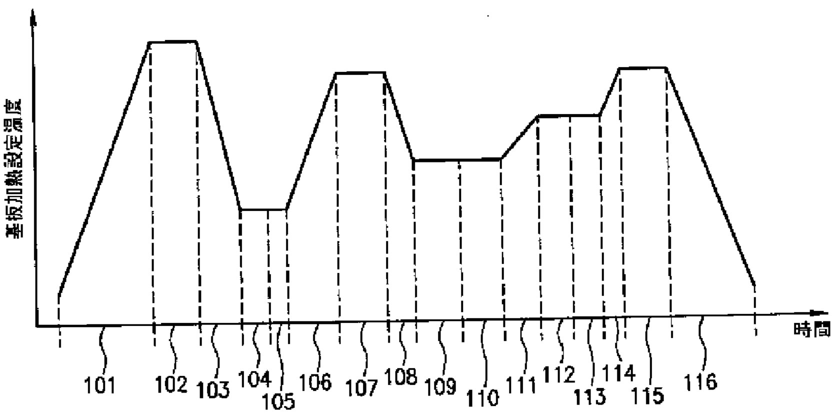
* NOTICES *

JPO and INPIT are not responsible for any damages caused by the use of this translation.

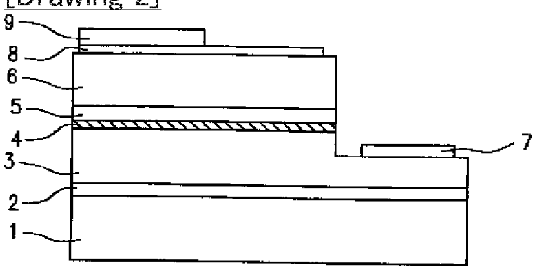
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

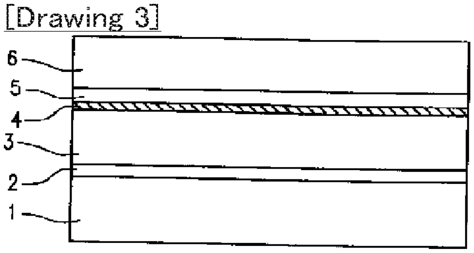
[Drawing 1]



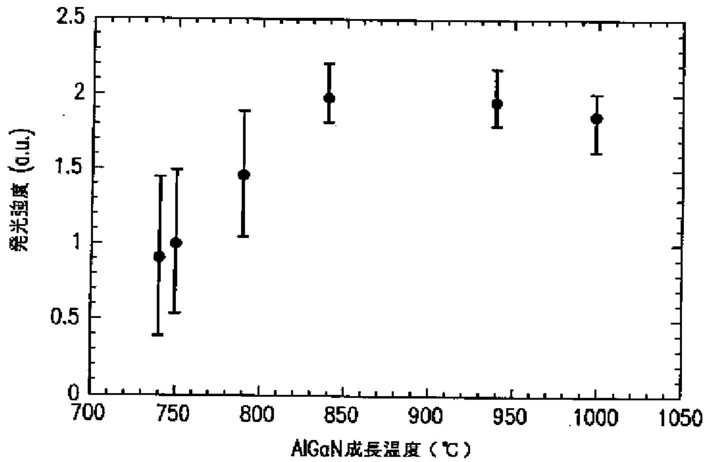
[Drawing 2]



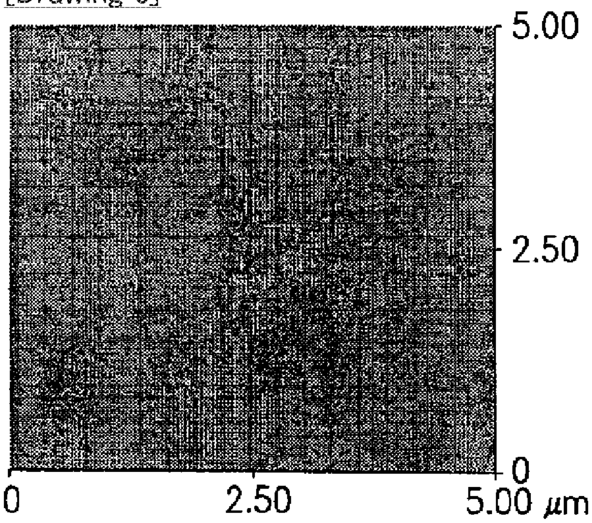
[Drawing 3]



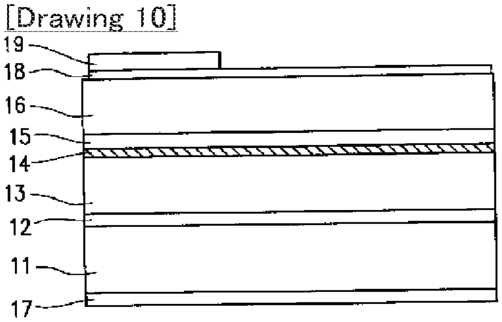
[Drawing 4]



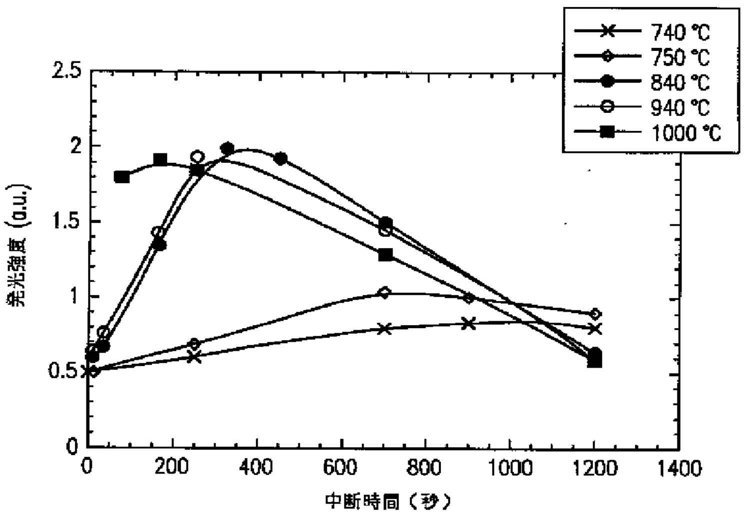
[Drawing 6]



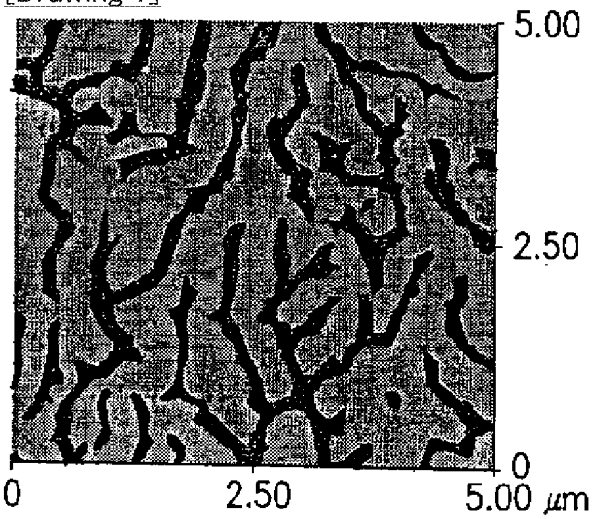
[Drawing 10]



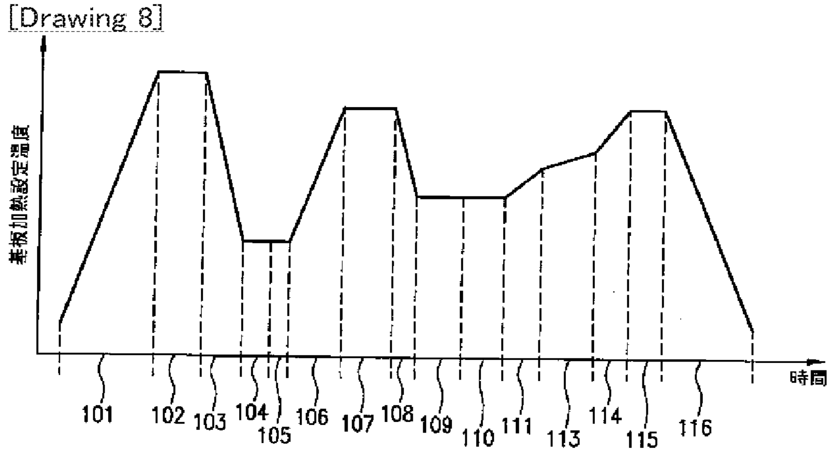
[Drawing 5]



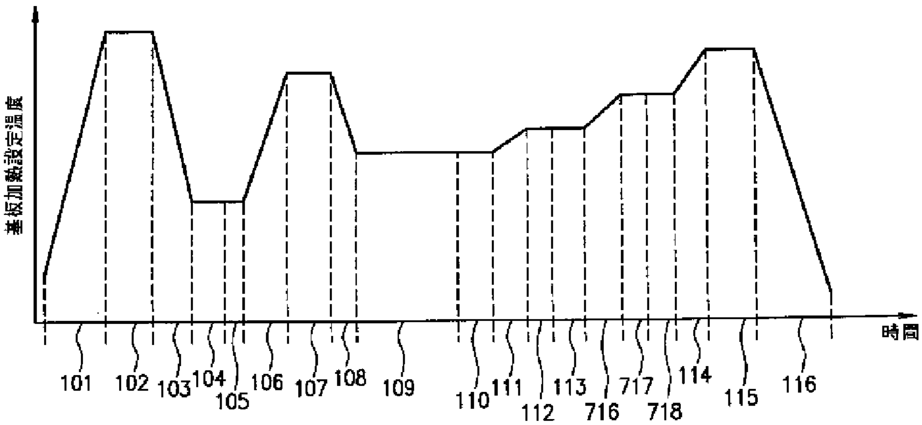
[Drawing 7]



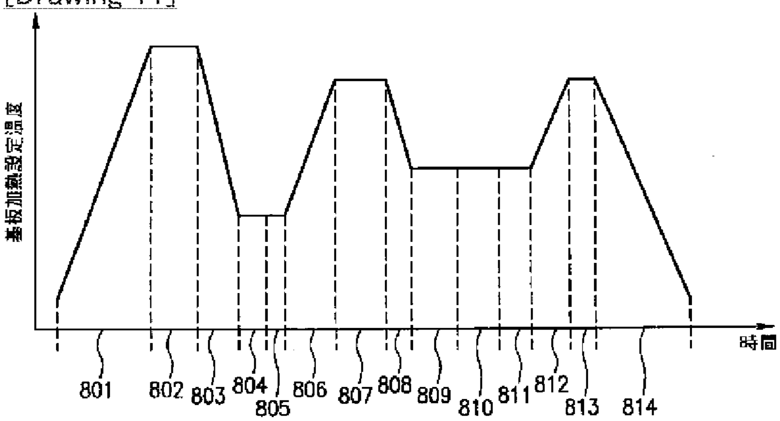
[Drawing 8]



[Drawing 9]



[Drawing 11]



[Translation done.]